ORIGINAL DOCUMENT BOOK

FINAL REPORT

NREL SUBCONTRACT NO.
ZXE-9-18080-01

BUILDING A BRIDGE TO THE CORN ETHANOL INDUSTRY

PREPARED FOR:

NATIONAL RENEWABLE ENERGY LABORATORY
Golden, Colorado

VOGELBUSCH PROJECT #9827

JANUARY 10, 2000

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TO: NREL
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TRANSMITTAL NUMBER: 03
DATE: January 11, 2000
VB PROJECT NO: 9827
SUBCONTRACT: ZXE-9-18080-01

ATTENTION: Mark Ruth
cc: Art Wiselogel
cc: John Enoch
cc: Robert Wooley & Pat Weitzel

TRANSMITTED HEREWITH ARE THE FOLLOWING:

[ ]	DRAWINGS	[ ]	SEPIA	[ ]	SPECIFICATIONS
[ ]	TRACINGS	[ ]	COPY OF LETTER	[X]	see below

COPIES	DESCRIPTION
1	Original Document Book containing the final summary report, PFD's , capital cost summary, and financial proformas and sensitivity analysis. This document book is intended for Mark Ruth.
4	Punched, working copies of the above report for distribution to Pat, Art, John and Bob.
	Please note:
	A zip disk containing the electronic files of the report will be sent under separate cover to Mark Ruth.

THESE ARE:

[X]	FINAL REPORT	[ ]	
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REMARKS: Mark,

Please call if you have any questions. We have really enjoyed working with you on this project.
Thanks for the time and effort that you have put into responding to our questions.

VERY TRULY YOURS,

PAM TETARENKO

EXECUTIVE SUMMARY

The economical feasibility of integrating a 23.5 million gallon per year (MMGPY) cellulose conversion facility into the existing 60 MMGPY Chief Ethanol Fuels grain alcohol production facility has been reviewed.

The project, under current market and technical conditions, does not generate a positive return on investment because of the following factors:

- The capital cost for the proposed facility is over $6/annual anhydrous gallon of alcohol produced vs. $1.50 to $1.80/annual anhydrous gallon of alcohol produced for current dry grain milling fuel alcohol facilities of similar capacities.

- The cash manufacturing cost, using corn stover as the feedstock to the NREL provided technology, is approximately $1.88/gallon of denatured alcohol vs. $0.90/gallon of denatured alcohol for current stand-alone dry milling alcohol facilities of similar capacity using corn at $2.10/bushel.

The major factors contributing to the very high capital and production costs are the complex and difficult pretreatment process, expensive incineration and turbogeneration equipment, the cellulase enzyme cost and the corn stover feedstock cost.

In order to break even and begin generating a positive cash flow, the following improvements need to be made:

- reduction in capital expenditure of 50%
- reduction in overall chemical cost of $0.20/gallon
- improvement in alcohol yield of 20%
- reduction in feedstock cost (collection and transport) of $10/dry short ton
- capital loan obtained at the prime lending rate (approximately 8.5%)

We feel that, although aggressive, these improvement targets are achievable and have been selected based on our experience in the development of the grain based fuel alcohol industry.

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Building a Bridge to the Corn Ethanol Industry
NREL Subcontract No. ZXE-9-18080-01

PROJECT OBJECTIVE & DESCRIPTION

A study was undertaken to determine the feasibility of integrating a biomass conversion facility into the existing Chief Ethanol Fuels plant in Hastings, Nebraska. This facility would hydrolyze biomass to sugars and ferment the resulting C5 and C6 sugars to fuel alcohol as the main product. A by-product of the process would be lignin which would be incinerated and used to generate steam and electricity. The steam and electricity would then be used in the process to reduce the cost of utilities.

The site specific business potential of producing ethanol from biomass at the Chief facility was evaluated. The biomass conversion process was integrated into the existing grain-processing infrastructure. The potential to take advantage of the grain-processing infrastructure in place at the Chief plant site and also the existing ethanol transport infrastructure for product delivery was investigated.

In addition to evaluating the economic and technical feasibility of integrating the NREL developed biomass conversion process into the existing Chief facility, suggestions for further research and development are discussed .

This work has been carried out by:

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Houston, TX 77043

with the participation and assistance of:

Chief Ethanol Fuels, Inc.
East Highway #6
Hastings, NE 68902

TASK 1 FEEDSTOCK DESCRIPTION

The feedstock for the existing Chief Ethanol facility is primarily milo with some corn depending on pricing and availability. The plant is presently producing 60 million gallons of fuel alcohol per year.

After discussions with Chief personnel, a meeting with local area farmers and a review of the available Nebraska crop data it was determined that a nominal plant capacity of 23.5 MMGPY would fit within the existing facility and site constraints as well as allow for a direct comparison of information received from a commercial source.

The corresponding daily usage of corn stover for the proposed facility is estimated to be 850 dry metric tonnes per day based on a yield of 300 litres of alcohol per dry metric tonne of stover. This yield was discussed with and confirmed to be valid for the purposes of this study by NREL. It is a balance between the NREL findings and best of industry information.

According to data presented by the University of Nebraska (Lincoln) in 1990 under the title "Nebraska Survey of Biomass", the necessary corn stover would be available within a 20-25 mile radius of the Hastings facility in Adams, Clay and Hall counties. This is felt to be an acceptable supply radius for transport of the bales of stover.

In order to further evaluate the potential corn stover supply and determine a site specific landed raw material cost a meeting was held on May 19, 1999 in Hastings, Nebraska with local area farmers. The attendees of this meeting and the organizations which they represented were:

Attendee	Organization(s) Represented
Dave Grams	Farmer / KAPPA (Kearney Area Ag. Producers Assoc.)
Steve Mercer	Farmer / KAPPA
Dennis Scamehorn	Farmer / Nebraska Corn Growers Association
Craig Hollister	Farmer / Adams & Webster County Corn Growers Assoc.
Roger Burken	Chief Ethanol Fuels
Duane Kristensen	Chief Ethanol Fuels
John Trumpeter	Chief Ethanol Fuels
Gunter Brodl	Vogelbusch U.S.A., Inc.
Pam Tetarenko	Vogelbusch U.S.A., Inc.

The objective of the meeting was to discuss the practical impact and trade-offs of collecting corn stover. The members of the group had previous experience with the collection of corn stover on a trail basis for a paper making facility in Kearney, Nebraska. Their findings are

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summarized as follows:

1. Harvestable yield is 2 short tons dry matter/acre (1.5 short tons/acre from frozen ground). This is approximately 40% of harvested corn weight (i.e., 400 tons stover per 1000 tons corn).

2. Square bales 3'x4'x8' are preferred for ease of handling and stacking. The weight is approximately 900 pounds of dry weight per bale (400 kg). A plant of 23.5 MMGPY capacity would process approximately 2100 bales of stover per day.

3. The stover was collected by a custom harvester contracted by the paper producer. Equipment used included a baler and stacker unit (hydraulic squeeze) to load bales.

4. The cost of harvesting, baling and stacking on the farmer's property or loading on trucks was $27/dry short ton.

5. The storage time required to cover through to the end of the next harvest would be 14-16 months. The square bales could be stacked 9 high. To lease land for storage purposes to provide space for 2000 short tons would cost approximately $300-$500 per annum.

6. Transport costs to the plant within a radius of 25 miles are assumed as $8.50 - $9.00/dry ton (from Hettenhaus, Bioenergy Report).

7. The return to the farmers would need to be further negotiated but initial indications are that it would need to be at least $7.50-$10/dry short ton in order to assure sustained supply and to cover mineral loss ($3-$5/dry short ton).

8. At present, corn stover competes with hay for animal feed. Some cattle farmers graze the stalks; on more sandy soil it is used for organic matter buildup and there are even a few farmers who still burn the fields.

Adding points 4, 6 and 7 together, the final landed cost at the Chief facility would be $43-$46/dry ton corn stover.

Given the size, density and stacking characteristics of the bales, and allowing for access of loading and unloading equipment from tractor-trailers, it is estimated that an area of a minimum of half an acre is required to store a day's production worth of corn stover. Given the climatic conditions during winter , we recommend at least six (6) days of storage on site. This would require three (3) acres. This additional land is available on grounds, already owned by Chief, adjacent to the existing plant.

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In addition to the experiences of the local Hastings farmers, the logistics and feasibility of collecting corn stover have been well presented in the paper by David A. Glassner, James Hettenhaus and Thomas Schechinger entitled "Corn Stover Collection Project" in the publication BioEnergy '98 for a pilot program in Harlan, Iowa.

Although the basis of this study is corn stover, wheat straw is also a potential cellulose feedstock for the Chief facility. Since harvest of wheat occurs approximately two months before the corn harvest, the extra storage requirements for corn stover could be reduced or possibly eliminated resulting in cost savings.

TASK 2 FACILITY DESCRIPTION

PFD's and Material Balance

The basis for the site specific material balance has been to factor the material balance supplied in NREL/TP-580-26157 for all areas outside of distillation and evaporation. The distillation and evaporation areas have been simulated by Vogelbusch distillation specialists, and the material balance corresponds to our standard Vogelbusch fuel ethanol distillation system. The original NREL material balance has also been adjusted to reflect corn stover instead of wood chips and outside purchase of cellulase enzyme.

The modifications to the front end design are minor. A new Area 100 PFD has been developed to reflect the handling of corn stover as opposed to wood chips. An additional seed vessel (WT-301B) has been added to Area 300 in order to provide the capability to do on-line cleaning/sterilization of one vessel while the other is in service. The cellulase enzyme will be purchased from a commercial source and not manufactured by Chief Ethanol Fuels and therefore the original NREL Area 400 PFD's are not included in this feasibility study. The current beerwell (T-306) had a residence time of 8 minutes. This has been increased to 4 hours in order to provide the inventory required to safely start-up or shutdown the distillation system.

The enzyme cost used in this study is $.30/gallon of alcohol produced. This cost information has been supplied by NREL and is based on pilot plant data.

Several modifications have been made to the distillation and evaporation area (Area 500) to improve operation and to lower capital costs. A separate stripping column (D-503) has been added in place of the bottom stripping section of the rectifying column (D-502) to lower costs. Additionally, side vapor draws have been added to D-502 to prevent the accumulation of high boiling byproducts. A mist eliminator (T-502) has been added to remove liquid carryover or slugs of liquid from the alcohol vapor feed to dehydration. Liquid carryover to the molecular

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sieve beds significantly affects performance. Ethanol content in the bottoms streams of the beer column (D-501) and stripping column (D-503) have been reduced from 500 ppm to 100 ppm. Finally, to minimize emissions, a degas cooler (H-504A) has been added downstream of the beer column overhead condenser (H-504).

Modifications to the molecular sieve unit include the addition of a dehydrated alcohol cooler and the removal of the purge/product exchanger. The purge recycle stream will be heated with the stripping column bottoms in the plate and frame exchanger H-502. The vacuum pump has been replaced with a two stage jet ejector package.

Streams containing solids tend to foul equipment and require occasional cleaning. Therefore, several changes were made to allow for uninterrupted operation of distillation during equipment cleanings. The beer column feed interchange exchanger (H-512 A/B) has been changed from a plate exchanger to a spiral exchanger. A plate and frame exchanger is not suitable in this service due to excessive fouling and plugging. A second beer column reboiler and pump have been added along with a direct steam line to the beer column (D-501). When one of the shell and tube reboilers is off line for cleaning, operation can continue using direct steam, or alternatively, beer feed rates can be reduced to distillation. Additionally, an evaporator feed flash tank (T-520) has been added to provide 12 hours of residence time to allow continuous operation of distillation while the evaporators are being cleaned.

Several improvements have also been implemented in the evaporation area. Process conditions have been changed so that two of the five shells have been eliminated, and the soluble solids concentration in the concentrated lignin has been increased to 32%. This may be overly aggressive for a present facility as discussions with NREL indicate a belief that approximately 28% is as high as has been previously tested for pumpability but we are assuming this will be achievable for an n^{th} facility. A required steam condensate flash drum (T-517) has also been added to allow for pumping of condensate. In addition, a necessary vacuum pump package (M-501) has been included.

Equipment List Notes

The equipment list for the Chief facility has been compiled using our standard Vogelbusch (VB) format. The equipment for all areas, other than corn stover handling and distillation, is based on the original NREL specifications with a scaling factor applied to account for the different capacity. The corn stover handling and milling equipment was specified and cost estimated based on our previous involvement in a feasibility study for use of baled switchgrass as a feedstock for fuel alcohol production and subsequent discussion with ABB Raymond. ABB Raymond is a leading supplier of air-swept, impact mill systems for fine grinding of various products, including sunflower hulls and wood waste. The distillation equipment has been selected and sized based on our internal simulation and standard fuel ethanol distillation design.

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The extensive VB equipment cost data base was used for estimating the cost of items which are similar to equipment that either we or our clients have purchased recently. It was necessary to used scaled factors supplied in NREL/TP-580-26157 (July 1999) for items for which we have little or no relative cost data. The equipment list clearly indicates when scaled factors were used.

The equipment list with cost data provides both a hybrid cost estimate employing Vogelbusch cost estimates and scaled cost estimates where appropriate as well as a completely scaled cost estimate for comparison purposes.

We have also included a cost column with installed equipment prices based on factors supplied in NREL/TP-580-26157 for comparison purposes. However, these factors were confirmed by NREL to not include electrical/wiring costs. The internal VB installation factors have been used for the final report.

Although individual costs for some items vary substantially, the final equipment costs (and installed equipment costs) for the two cost estimating exercises are remarkably similar.

Following are more detailed notes in regards to the technical differences summarized at the beginning of this section. Only those process areas impacted are presented:

AREA 100 – Stover Handling and Milling

The process proposed for size reduction of corn stover, delivered in bales to the plant site, has been substantially changed from that proposed for wood chips. The scheme incorporates a flat storage building for storage of the bales. The bales are fed to a two-stage shredding system, followed by air-swept, impact hammermills. Four identical trains, each with a capacity of 33%, are to be used so that routine and non-routine maintenance can be performed on any one train without impacting plant throughput. The milled stover is pneumatically conveyed to a weigh belt for precise metering of feedstock to Area 200 – Preparation.

AREA 300 – Fermentation

Based on VB experience dealing with beer containing insoluble solids, welded plate VICARB heat exchangers have been selected for this area.

Our experience also shows that much more uniform agitation is achieved with the use of top-mounted agitators. As a result, we have specified one top-mounted agitator for each of the 18 SSCF fermenters rather than the two side-mounted agitators used in NREL/TP-580-26157.

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AREA 400 – Cellulase Production

It was decided that cellulase will be purchased from an industrial enzyme supplier rather than producing the enzyme on site. As a result, this area was eliminated and the cost used in the proformas for enzymes was taken to be $0.30/gallon of ethanol. This cost is based on the NREL cost to produce the cellulase enzyme in the pilot plant. Comparison with a commercial supplier showed a much different cost however. The cellulase enzymes on the market today cost well over $1.00/gallon of ethanol produced and would render the project unviable. As this plant is intended to be an nth generation plant, we have completed the final proformas using $0.30/gallon. This is a critical area that requires further investigation in regards to both on-site production and improvements in commercial supply/cost.

AREA 500 – Distillation/Evaporation/Molecular Sieve Dehydration

Since our scheme in this area differs substantially from that proposed in NREL/TP-580-26157, we have included our database cost estimate for two spiral heat exchangers in the completely scaled estimate as well so that the comparison remains valid.

An evaporator feed tank with enough residence time to do periodic cleaning of the evaporator without impacting plant throughput is also included in both estimates.

Integration with the Existing Facility

Raw materials and the two processes up to the end of fermentation (including the Beer Column) are fundamentally different (i.e., different organisms utilized, recovery of DDGS). Therefore, internal process integration has not been reviewed. The following factors have been reviewed:

Utilities

The possibility of sharing steam back and forth between the existing process and the proposed cellulose conversion process has been reviewed. The current Chief boilers produce sufficient steam to start the cellulose plant. For ongoing operation, exhaust steam from the turbogenerator will be used.

The electricity required for the process is supplied, in part, by the turbogenerator in Area 800. There will be a small deficit in electricity available vs. electricity required. The electricity required has been determined by factoring the original NREL base case to adjust for capacity. The deficit will be made up by supplying natural gas to the boiler. At a cost of $2.50/MMBTU

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for natural gas vs. a cost of $44/dry ton of stover, it is not cost effective to utilize excess stover as boiler fuel.

The cooling towers will remain separate due to the fact that the existing cooling tower is running at capacity and the cost savings of expanding this unit versus the cost of a new cooling tower would likely be offset by the increased cost to replace the existing cooling water piping which is too small to handle the distribution for both plants.

Product Mix and Marketing Structure

The expanded process does not introduce any "new" products from a sales perspective and therefore the existing marketing structure would remain essentially as is. The absence of air in the *Z. mobilis* fermentation could potentially make the overall carbon dioxide produced more attractive to CO_2 processors. The existing CO_2 is currently scrubbed of alcohol and organic acids and then vented to the atmosphere. Since Chief does not currently sell CO_2, the decision has been made to not include the sale of CO_2 in the projections for this project at this stage.

Organizational Infrastructure

The existing lab facilities, maintenance, management and administration systems would not require any major changes. Additional manpower to operate the cellulose facility has been included in the proformas.

Water Treatment

The current waste water system is operating at maximum capacity. A separate water treatment facility has been included in the cost of the cellulose conversion process plant.

Alcohol Storage & Loadout

Alcohol storage and loadout facilities could be shared.

TASK 3 CAPITAL AND OPERATING COST REFINEMENT

The installed capital cost and cash manufacturing cost for the proposed facility have been estimated. Under the current market and technical conditions, the project does not generate a positive return on investment because of the following factors:

- The capital cost for the proposed facility is over $6/annual anhydrous gallon of alcohol produced vs. $1.50 to $1.80/annual anhydrous gallon of alcohol produced for current dry

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grain milling fuel alcohol facilities of similar capacities.

- The cash manufacturing cost is approximately $1.88/gallon of denatured alcohol vs. $0.90/gallon of denatured alcohol for current stand-alone dry milling alcohol facilities of similar capacity using corn at $2.10/bushel.

The detailed cost data and financial summaries are presented in the Financial Proformas and Sensitivity Analysis section.

TASK 4 & 5 FINANCIAL PROFORMAS & SENSITIVITY ANALYSIS

A financial analysis of the long-term operation of the proposed cellulose conversion facility to be located adjacent to the existing Chief Ethanol Fuels grain to fuel alcohol facility in Hastings, Nebraska has also been prepared.

A "Base Case" evaluation, incorporating site specific capital costs, operating costs, feedstock costs, and final products market value is provided.

Also included is a "Target Case", which makes the following adjustments to the "Base Case":

- Ethanol yield from stover is increased 20%
- Delivered stover price is reduced by $10 per dry U.S. ton
- Chemical costs are reduced from $0.50 to $0.30 per anhydrous ethanol gallon
- Installed cost of the facility is reduced from $6.22 to $3.00 per annual gallon
- Loan interest rate is reduced from 10% to the current prime lending rate of 8.5%

Each analysis consists of the following:

- Sources and Application of Funds (Year 1)
- Sources and Application of Funds (Year 2)
- Balance Sheet (Years 1 through 12)
- Income Statement (Years 1 through 12)
- Cash Flow Statement (Years 1 through 12)
- Pricing Sensitivity Matrix - Average Annual Pre-tax Income (Years 3 through 12)
- Pricing Sensitivity Matrix - Average Annual Cash Flow (Years 3 through 12)

In regards to the "Target Case", we feel that the targets stated are aggressive, but achievable, for the following reasons:

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- Ethanol yield

  The ethanol yield used in this study is an average of the current NREL yield and the current best of industry. Therefore, we feel it is reasonable to assume that the average yield will continue to move towards the current best of industry.

- Delivered stover price

  The site specific feedstock cost used for this study is higher than the feedstock cost determined in a parallel field study conducted in a different location. For this reason, we feel it is reasonable to assume that the overall collection and transport costs will continue to improve and become more consistent from state to state.

- Chemical cost reduction

  We feel that an anticipated higher demand for cellulase enzymes will lead to improved production technologies and reduced prices. This trend has been very dramatically demonstrated with almost all enzymes which have found large-scale industrial applications.

  We also feel that it is reasonable to assume that as the pretreatment technology continues to improve there will be a reduction in the usage of other chemicals (i.e., ammonia and sulfuric acid).

- Capital and cost reductions

  The targets for capital cost improvements reflect our experience in the development of the grain alcohol industry over the past 20 years. For example, in 1980 the installed capital cost to build a comparable grain alcohol facility was $3.00 - $3.50/annual gallon anhydrous alcohol. This same facility can now be constructed for approximately $1.50 - $1.80/annual gallon anhydrous alcohol. Taking inflation into consideration would show an even more dramatic decrease in capital cost.

- Loan interest rate

  Both state and federal governments have shown a willingness in the past to support renewable fuel projects with grants, guarantees, and low interest loans. For this reason, we feel it is reasonable to assume that, at the very least, a loan at the current prime lending rate of 8.5% could be secured for the proposed biomass-to-ethanol project.

The detailed financial projections for both cases are presented in the Financial Proformas and

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Sensitivity Analysis section.

CONCLUSIONS

The concept of building biomass-conversion facilities next to existing ethanol plant sites is certainly worthy of investigation. However, based on the costs and prices determined in this report, a nominal 23,000,000 gallon per year fuel ethanol facility proposed for the Chief Ethanol Fuels facility in Nebraska loses an average of over $22,000,000 per year for the first ten years of full operation.

Unfortunately, the proposed project, as presented, is not economically feasible. The items of specific concern are as follows:

- The facility is too expensive to build. The estimated capital investment of approximately $6.22/annual gallon of ethanol production reflects a need to further review the process technology as well as the equipment required. Grain alcohol plants of similar capacity can be constructed for approximately $1.80-$2.00/gallon.

- The chemical and enzyme costs of $0.50/gallon of ethanol are cost prohibitive. Current state-of-the-art corn-to-ethanol facilities have a chemical and enzyme cost of approximately $0.10/gallon. The primary culprit is the cellulase enzyme. The $0.50/gallon already assumes the less costly option of producing enzyme on site at the NREL pilot plant cost of $0.30/gallon of ethanol. As discussed previously, the currently available commercial enzymes would result in enzyme costs alone of greater than $1.00/gallon ethanol which would render the project infeasible. Although it is likely safe to assume that cellulase costs will dramatically decrease as demand (and competition) increase, at this time, the option to produce the enzyme on-site should not be ruled out.

- The landed corn stover cost at the Chief facility of $43-$46/dry ton is too expensive. Even the previously published figure of $32/dry ton, which is an anticipated cost in the Iowa area, is cost prohibitive with current technology. At $44/dry ton, the cost of corn stover required to produce ethanol (not including any additional stover used for boiler fuel) is nearly $0.61/gallon of ethanol. Using a typical corn-to-ethanol yield of 2.6 gallons/bushel for comparison, this is approximately equivalent to corn at $1.60/bushel. Although the use of corn stover results in little or no byproduct credit, treating and burning lignin for steam does result in an elecricity and natural gas savings or "credit" of about $0.15/gallon of ethanol. On the other hand, DDGS selling at $100/ton would result in a credit of $0.35/gallon of ethanol. Comparing corn and corn stover on a feedstock and byproduct/energy credit basis, it follows that corn stover at $44/dry ton is roughly equivalent to corn at $2.10/bushel. However, corn stover costs would need to be much lower in order to justify the increased capital investment and operating costs associated with the proposed biomass project.

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RECOMMENDATIONS

Some or all of the following are necessary in order to make corn stover (or any cellulose containing material, for that matter) attractive as a feedstock for the production of fuel ethanol:

- An alternative or modified process that would result in much reduced capital and enzyme/chemical costs needs to be identified. To address the capital cost issues further, technical development work is required. The dilute acid process, with the very difficult to define overliming step, requires expensive materials of construction as well as expensive individual process items such as the Ion Exchange System.

- Enzyme costs need to be addressed further. The state of the current industry, in regards to commercial enzyme supply, makes the option to produce cellulase enzymes on site an important one to review further. The current enzyme industry does not have the production plants on line to supply a full-fledged cellulose conversion industry at this time. There will be a transition period for the first few cellulose plants that needs to be planned for. It is uncertain how scaleable the current enzyme processes are as well. Technical enhancements may need to be developed in this area.

- Methods to reduce feedstock cost must be identified. This could be corn stover, another harvested crop, or some waste product.

- In regards to corn stover and other cellulose sources with similar physical characteristics, pilot plant research with these specific feedstocks needs to be conducted. The work, to date, has primarily involved wood chips and while some useful parallels can be drawn, the handling and pre-processing (i.e., shredding, screening, etc.) of different materials needs to be addressed in more detail.

- The robustness of the zymomonas to "upsets" in process conditions needs to be investigated further.

- Governmental investment, either in the form of low interest loans or grants, which would help to offset the high initial capital cost required, would be one approach to reaching the commercialization stage.

- A state or federal production incentive (over and above the current federal excise tax exemption) is one possible way to help offset high operating costs.

- Alternative uses for lignin (rather than the current scheme of burning it for steam production) need to be developed. This would increase revenues in the form of byproduct credits and

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decrease initial capital costs associated with lignin incineration equipment.

- Explore the possibility of selling the scrubbed carbon dioxide from both the proposed facility and the existing facility to a third party. A carbon dioxide processor may be interested in locating a facility adjacent to the ethanol plant.

CLOSING SUMMARY

In this study we have strived to provide an unbiased and realistic assessment of the economics of conversion of corn stover to ethanol in a typical situation. We have not attempted to critique or change current technology but have pointed out possibilities for improvements by comparison of available information from various sources.

When undertaking a study of a complexity such as this one, there is a danger of losing the original purpose and goals of the project as a result of focusing on details.

The principle goals of this project were:

A. Provide the grain processing industry the opportunity to explore the business potential of converting biomass to sugars via hydrolysis and fermentation to products such as ethanol.

By selecting a partner from the ethanol industry who was centrally located in the Corn Belt, we feel we could examine a representative case for the alcohol industry. Not only was it possible to look at the synergy between an existing grain alcohol plant and a future biomass alcohol plant but it was also possible to gain insights on how such an undertaking would fit in with the farming community.

While much work needs to be done to improve the economics of the biomass to alcohol technology, we feel that in the medium to long term there is tremendous potential for future utilization of such an emerging process. Given the uncertainties which are prevalent in the world energy and food supply for the next century, the use of an agricultural co-product which is readily available will certainly remain attractive.

Agricultural wastes are not subject to the wide price fluctuations of commodities which are traded on the world market and would have a steadying influence on the price of ethanol fuels.

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(713) 461-7374 / FAX: (713) 461-7377

B. Take advantage of the grain processing infrastructure by investigating the location of biomass conversion facilities at existing plant sites.

While there are obvious synergies in terms of infrastructure and shared facilities, the study shows that these advantages would not outweigh the selection of a site based on its own merits. It is felt that the biomass to alcohol facilities will need to be considerably larger in size to reduce specific capital costs and, therefore, co-location on existing facilities might not be advantageous. The selection of sites will, in all probability, be governed by the availability of the cheapest possible raw materials. We feel that the initial biomass alcohol plants will use waste products which are available at no cost or even at a credit to the operation. These plants will, in all likelihood, be situated away from existing alcohol plants.

The experience gained from those initial plants and the resulting improvements in technology will then make it possible to design second-generation plants which are larger in size and utilize more widely available raw materials. These activities coupled with on-going research of both fundamental and practical aspects should make it possible to arrive at economically feasible solutions which can then more readily be integrated with existing grain alcohol facilities.

C. Obtain feedback from the grain processing industry to guide the research and development activities for biomass conversion and commercialization.

We have identified the three major areas which affect the economics as capital costs, raw material costs and chemical (enzyme) costs.

The improvements in capital costs will involve not only improvements in basic technology to streamline the process, especially the pre-treatment and fermentation sections of the plant, but will also require the input of industry to provide the know-how to reduce equipment and construction costs. In this respect, a continued and even closer cooperation between research institutes and industry sources would be helpful.

The selection of feedstocks and improvements in harvesting technology are already being investigated. We feel some effort should be made to see if the mineral content of the agricultural wastes can be recycled onto the land so as to avoid depletion of vital elements.

On the other hand, it is felt that the waste materials produced by the existing “overliming” process will be more and more detrimental as time goes on. Any successful biomass-to-ethanol facility will have minimal environmental impact, as well as a positive role in reducing

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greenhouse gas effects. Further research is required to find alternatives to avoid or remove inhibitory side products.

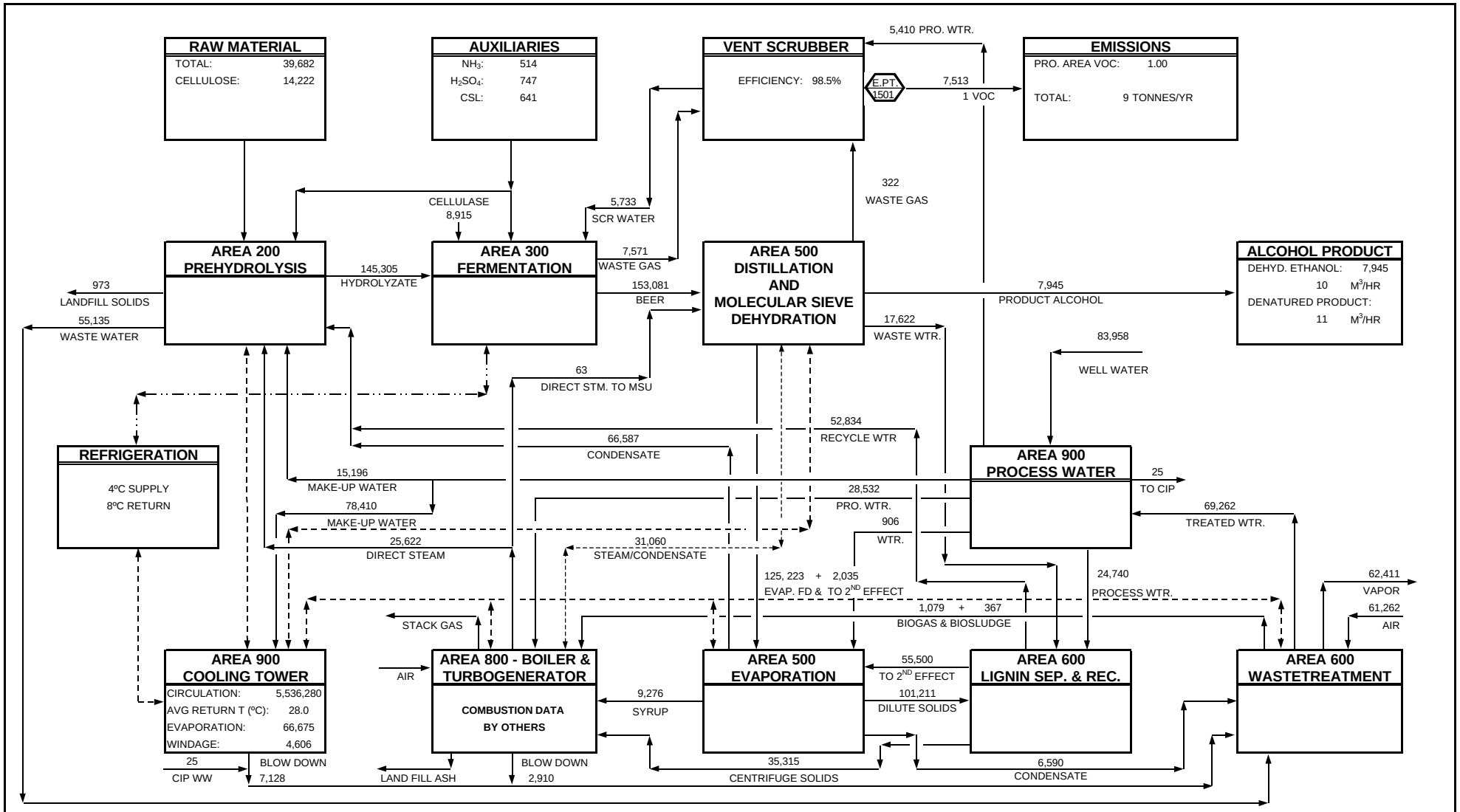
Further research into enzyme production technology and possible designs of simple and cost effective co-production of enzymes on site should also be a major focus for future development efforts.

As a final thought, we would say that biomass to ethanol technology is one of many alternate energy routes and we are of the opinion that all of them will be needed simultaneously in some form or another in the future. We, therefore, look at this emerging technology as complementary to the existing grain alcohol technology rather than as a replacement. By combining the resources of research institutes with the experience and know-how of the grain alcohol industry, the biomass research projects of today will form the basis of a new industry in the not-too-distant future.

ACKNOWLEDGEMENTS

We would like to acknowledge those organizations who have contributed to this study. Through their very valuable input we have been able to conduct a comprehensive technical and financial review of the feasibility of integrating a cellulose conversion facility into the Chief Ethanol Fuels facility in Hastings, Nebraska. With their input, we have also been able to pinpoint what we feel to be the critical points that need to be addressed in moving towards the commercialization of cellulose conversion in general.

- Chief Ethanol Fuels, Inc. (Hastings, Nebraska)
- Kearney Area Ag. Producers Association (KAPPA - Kearney, Nebraska)
- Nebraska Corn Growers Association
- Adams & Webster County Corn Growers Association
- National Renewable Energy Laboratory (Golden, Colorado)
- Swan Biomass Company (Oak Brook Terrace, Illinois)
- Enzyme Development Corporation (New York, New York)
- Alltech, Inc. (Nicholasville, Kentucky)
- ABB Raymond (Lisle, Illinois)



NOTES
1. FIGURES IN KG/HR UNLESS OTHERWISE INDICATED.

NO.	REVISIONS	BY	CHK.	DATE	APPR.
0	FINAL (NO CHANGES FROM PRELIMINARY)	PT	GB	01/10/00	
A	PRELIMINARY	PT	GB	09/30/99	

ENGINEERING RECORD	
DATE:	9/28/99
SCALE:	NONE
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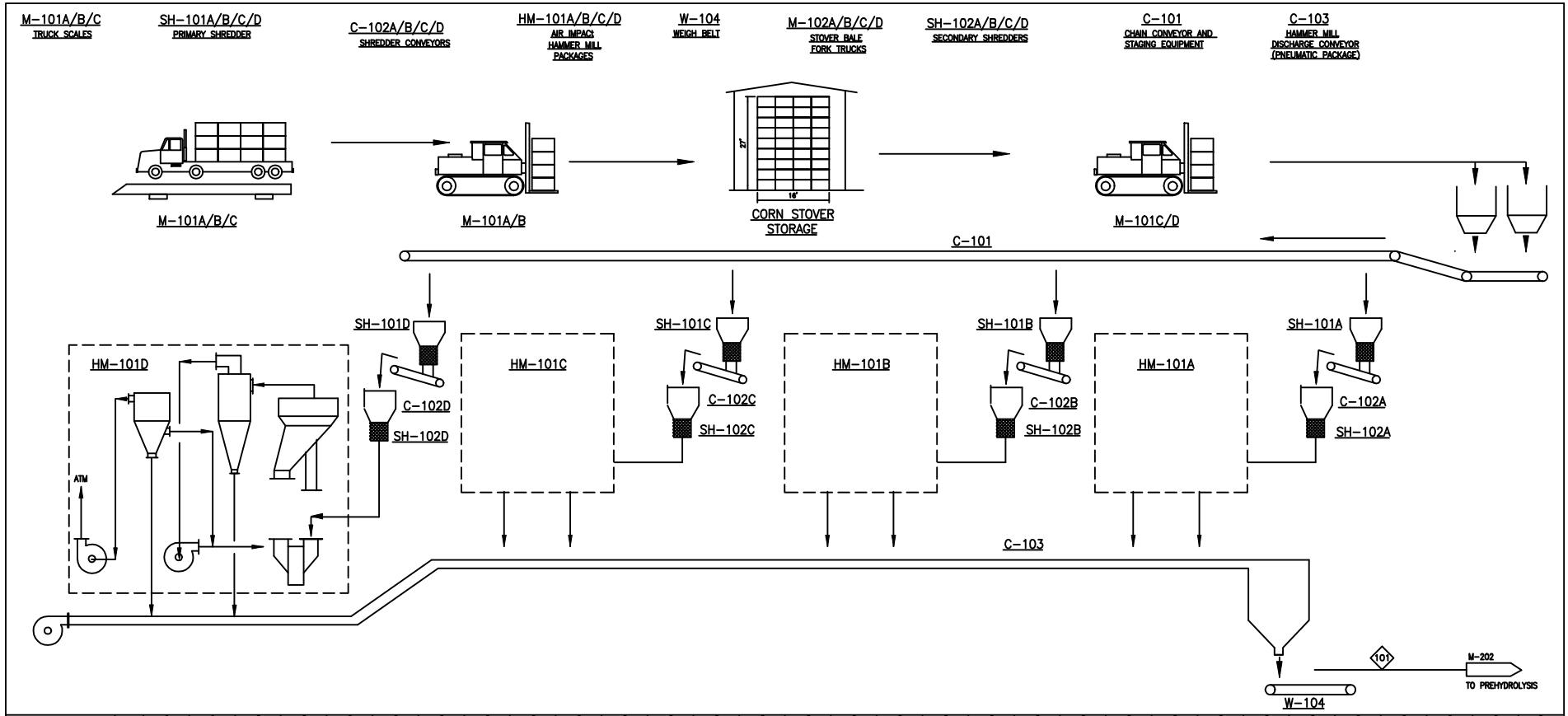
NREL
Hastings, NE
BLOCK FLOW DIAGRAM
CAPACITY: 23.5 MM GPY

PROJECT NO.	DRAWING NUMBER				
	SIZE	AREA	TYPE	SEQUENCE	REVISION
9827		GEN	N	00	0

5/10/00



STREAM NUMBER	UNITS	101	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇
STREAM NAME																																					
TOTAL FLOW	kg/hr	39,682.4																																			
INSOLUBLE SOLIDS	%	84.0%																																			
SOLUBLE SOLIDS	%	0.0%																																			
TEMPERATURE	°C	20																																			
PRESSURE	atm	1.00																																			
ETHANOL	kg/hr	0.0																																			
WATER	kg/hr	6,349.2																																			
GLUCOSE (SS)	kg/hr	0.0																																			
XYLOSE (SS)	kg/hr	0.0																																			
ACETIC ACID	kg/hr	0.0																																			
CELLULOSE (IS)	kg/hr	14,222.4																																			
OTHERS	kg/hr	19,110.8																																			

DWG. No.	REFERENCE DRAWINGS

No.	DATE	REVISION	BY	CK'D	APPR.
0	01/10/00	FINAL	RML	PT	
A	09/04/99	PRELIMINARY	RML	DM	

ENGINEERING RECORD
DATE: 08/18/99
SCALE: NONE
DRAWN BY: LANIER
CHECKED BY: DM
APPROVAL:
APPROVAL:

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HOUSTON, TEXAS

NREL NATIONAL RENEWABLE ENERGY LABORATORY
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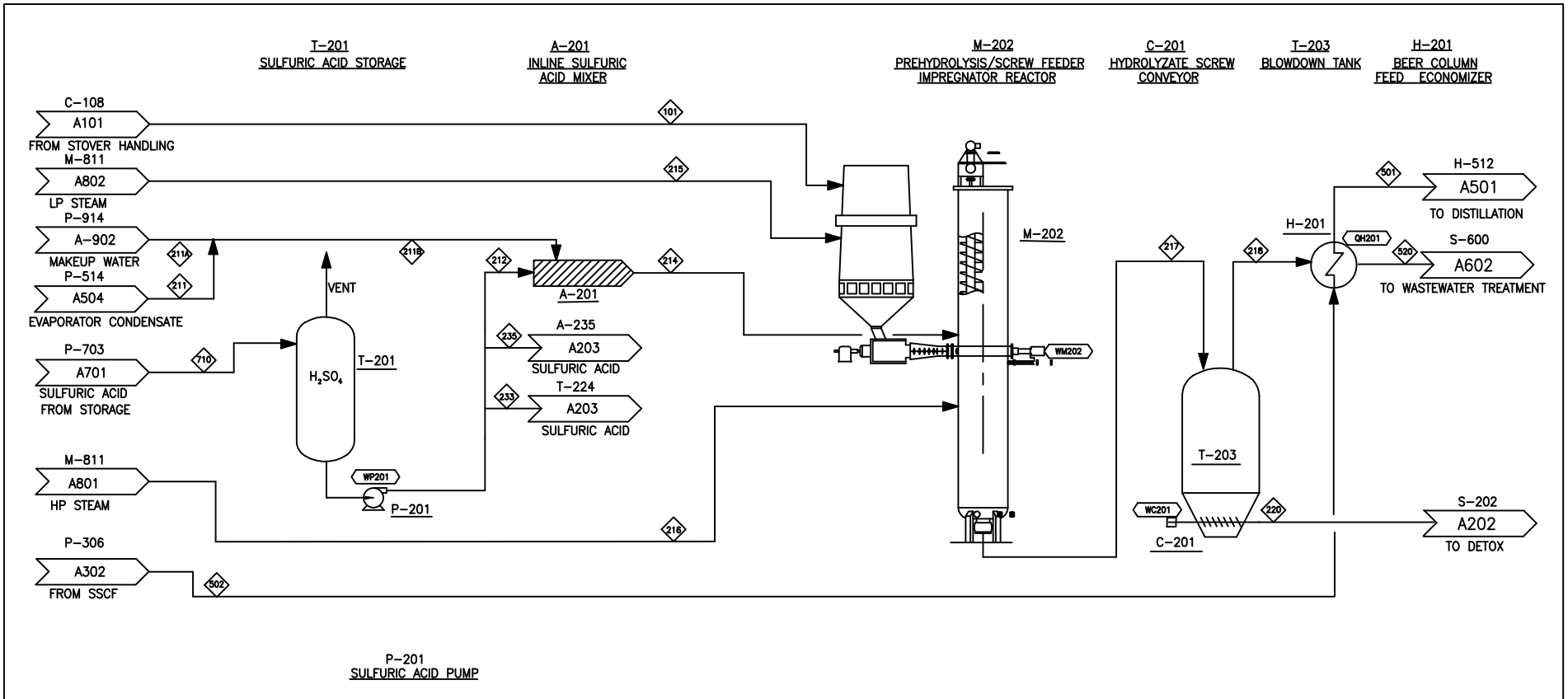
NREL

PROCESS FLOW DIAGRAM
SECTION A100
CORN STOVER HANDLING

PROJECT NUMBER	DRAWING NUMBER				
9827	D-100-N-A101				0
Client	Size	Area	Type	Sequence	Rev.

D100NA101.DWG

01/10/00



P-201
SULFURIC ACID PUMP

STREAM NUMBER	UNITS	101	211	211A	211B	212	214	215	216	217	218	220	233	235	501	502	520	710	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇
STREAM NAME																																		
TOTAL FLOW	kg/hr	39,682.4	28,310.6	15,196.0	43,506.6	368.8	43,875.4	6,784.0	17,838.4	108,180.2	18,079.4	90,100.8	121.6	256.4	153,081.3	153,081.3	18,079.14	746.8																
INSOLUBLE SOLIDS	%	84%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	21.8%	0.0%	26.1%	0.0%	0.0%	8.7%	8.7%	0.0%	0.0%																
SOLUBLE SOLIDS	%	0.0%	0.3%	0.0%	0.2%	0.0%	0.2%	0.0%	0.0%	7.9%	0.1%	9.5%	0.0%	0.0%	3.0%	3.0%	0.1%	0.0%																
TEMPERATURE	°C	20	54	24	44	20	43	164	268	190	101	101	20	20	93	30	100	20																
PRESSURE	atm	1.00	3.06	1.00	2.34	3.40	4.00	4.42	13.00	12.20	1.00	1.00	3.40	3.40	0.90	0.90	1.00	1.00																
ETHANOL	kg/hr	0.0	4.6	0.0	4.6	0.0	4.6	0.0	0.0	4.6	3.5	1.1	0.0	0.0	7,906.2	7,906.2	3.5	0.0																
WATER	kg/hr	6,349.2	27,818.5	15,196.0	43,014.5	0.0	43,014.5	6,784.0	17,838.4	73,234.4	17,554.0	55,680.4	0.0	0.0	122,680.8	122,680.8	17,554.0	0.0																
GLUCOSE (SS)	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,027.2	0.0	1,027.2	0.0	0.0	92.9	92.9	0.0	0.0																
XYLOSE (SS)	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5,413.2	0.0	5,413.2	0.0	0.0	306.2	306.2	0.0	0.0																
ACETIC ACID	kg/hr	0.0	250.3	0.0	250.3	0.0	250.3	0.0	0.0	1,796.7	116.9	1,679.8	0.0	0.0	1,074.8	1,074.8	116.9	0.0																
CELLULOSE (IS)	kg/hr	14,222.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13,098.8	0.0	13,098.8	0.0	0.0	1,537.3	1,537.3	0.0	0.0																
OTHERS	kg/hr	19,110.8	237.2	0.0	237.2	368.8	606.0	0.0	0.0	13,605.2	405.0	13,200.2	121.6	256.4	19,483.0	19,483.0	405	746.8																

DWG. No.	REFERENCE DRAWINGS

No.	DATE	REVISION	BY	CK'D	APPR.
0	01/10/00	FINAL	RML	DM	
A	09/04/99	PRELIMINARY	RML	DM	

ENGINEERING RECORD
DATE: 06/25/99
SCALE: NONE
DRAWN BY: LANIER
CHECKED BY: DM
APPROVAL:
APPROVAL:

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10810 OLD KATY ROAD, SUITE 107
HOUSTON, TEXAS

NREL
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Biotechnology Center For Fuels And Chemicals

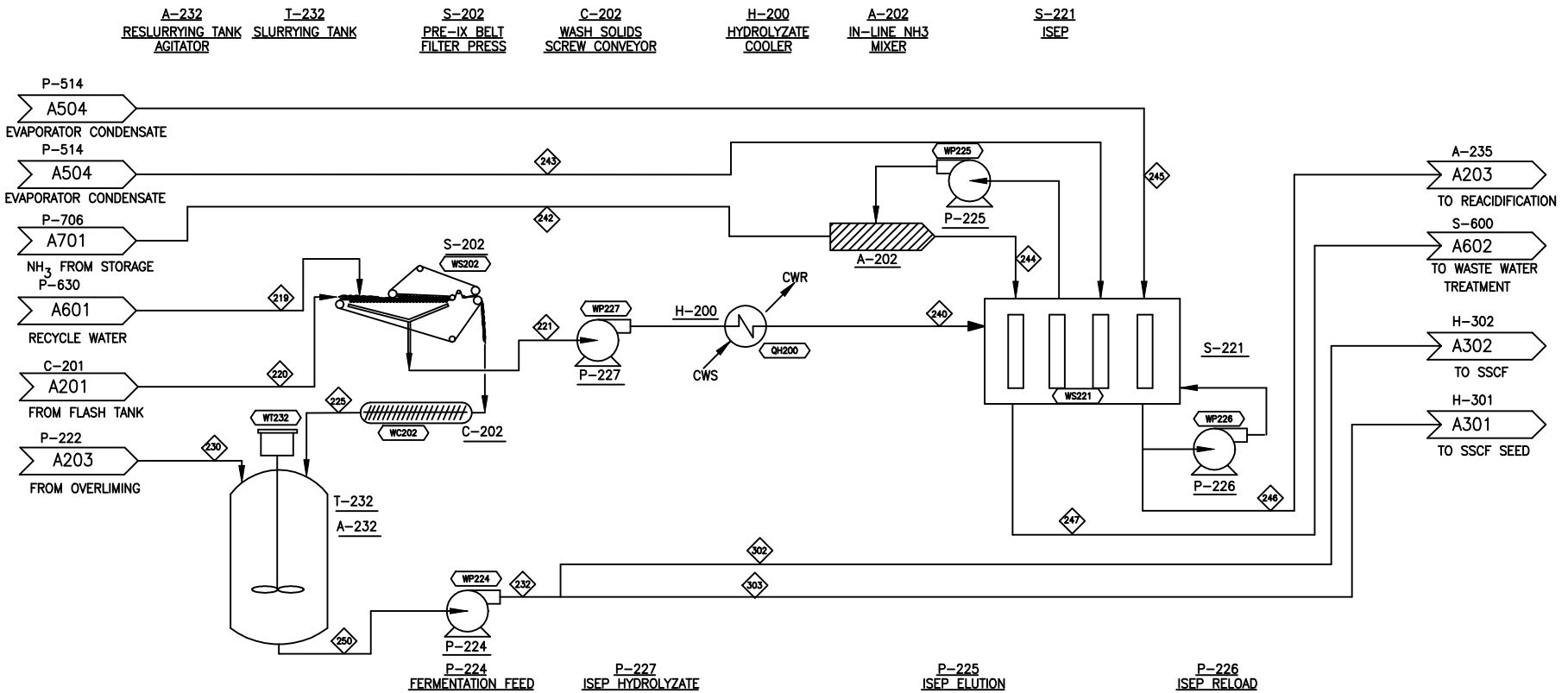
NREL

PROCESS FLOW DIAGRAM
SECTION A200
PREHYDROLYSIS

PROJECT NUMBER	DRAWING NUMBER				
9827	D-200-N-A201				0
Client	Size	Area	Type	Sequence	Rev.

D200NA201.DWG

01/10/00



STREAM NUMBER	UNITS	219	220	221	225	230	232	240	242	243	244	245	246	247	250	302	303
STREAM NAME																	
TOTAL FLOW	kg/hr	52,834.1	90,100.8	83,983.1	58,951.8	86,352.8	145,304.6	83,983.1	455.6	26,331.2	26,786.8	11,944.8	85,538.0	37,056.4	145,304.6	131,560.6	13,744.0
INSOLUBLE SOLIDS	%	0.2%	26.1%	0.1%	39.9%	0.0%	16.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	16.2%	16.2%	16.2%
SOLUBLE SOLIDS	%	1.1%	9.5%	7.6%	4.6%	7.4%	6.3%	7.6%	0.0%	0.0%	0.0%	0.3%	7.5%	4.9%	6.3%	6.3%	6.3%
TEMPERATURE	°C	47	101	75	75	51	59	40	20	73	50	74	40	40	59	59	59
PRESSURE	atm	1.00	1.00	1.00	1.00	1.00	1.00	1.00	17.00	3.00	3.00	3.00	3.00	3.00	1.00	1.00	1.00
ETHANOL	kg/hr	7.2	1.1	5.1	3.2	17.2	20.8	5.1	0.0	0.0	0.0	9.6	17.2	0.0	20.8	18.8	2.0
WATER	kg/hr	51,286.7	55,680.4	75,160.7	31,806.4	79,035.5	110,841.9	75,160.7	0.0	26,331.2	25,849.2	11,808.0	78,214.0	35,157.2	110,841.9	100,357.6	10,484.3
GLUCOSE (SS)	kg/hr	0.0	1,027.2	722.0	305.2	720.8	1,026.0	722.0	0.0	0.0	0.0	0.0	722.4	0.0	1,026.0	928.8	97.2
XYLOSE (SS)	kg/hr	43.7	5,413.2	3,835.3	1,621.5	3,828.8	5,450.4	3,835.3	0.0	0.0	0.0	0.0	3,837.6	0.0	5,450.4	4,934.4	516.0
ACETIC ACID	kg/hr	180.3	1,679.8	1,354.1	505.9	124.4	630.3	1,354.1	0.0	0.0	0.0	51.6	124.8	0.0	630.3	570.7	59.6
CELLULOSE (IS)	kg/hr	6.0	13,098.8	46.9	13,057.9	0.4	13,058.3	46.9	0.0	0.0	0.0	0.0	65.6	0.0	13,058.3	11,823.1	1,235.2
OTHERS	kg/hr	1,310.3	13,200.2	2,859.0	11,651.5	2,625.7	14,276.9	2,859.0	455.6	0.0	937.6	75.6	2,556.4	1,899.2	14,276.9	12,927.1	1,349.7

DWG. No.	REFERENCE DRAWINGS

No.	DATE	REVISION	BY	CK'D	APPR.
0	01/10/00	FINAL	RML	PT	
A	09/04/99	PRELIMINARY	RML	DM	

ENGINEERING RECORD
DATE: 06/22/99
SCALE: NONE
DRAWN BY: LANIER
CHECKED BY: DM
APPROVAL:
APPROVAL:

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HOUSTON, TEXAS

NATIONAL RENEWABLE ENERGY LABORATORY
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NREL

PROCESS FLOW DIAGRAM
SECTION A200
DETOXIFICATION

PROJECT NUMBER	DRAWING NUMBER				
9827	D-200-N-A202				0
Client	Size	Area	Type	Sequence	Rev.

D200NA202.DWG

01/10/00

A-235
IN-LINE ACIDIFICATION MIXER

C-225
LIME SOLIDS FEEDER

S-227
LIME DUST VENT BAGHOUSE

T-220
LIME STORAGE BIN

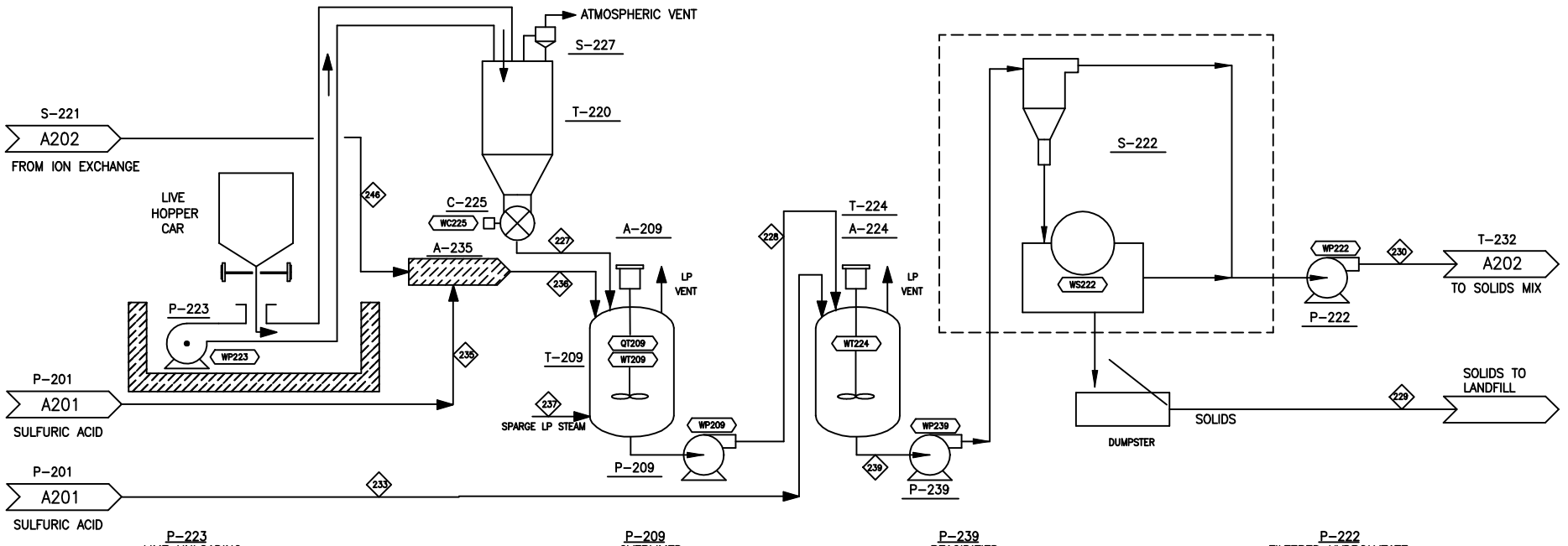
T-209
OVERLIMING TANK

A-209
OVERLIMING TANK AGITATOR

T-224
REACIDIFICATION TANK

A-224
REACIDIFICATION TANK AGITATOR

S-222
HYDRODONE & ROTARY DRUM FILTER



P-223
LIME UNLOADING BLOWER

P-209
OVERLIMED HYDROLYZATE PUMP

P-239
REACIDIFIED LIQUOR PUMP

P-222
FILTERED HYDROLYZATE PUMP

STREAM NUMBER	UNITS	227	228	229	230	233	235	236	237	239	246	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇
STREAM NAME																																		
TOTAL FLOW	kg/hr	285.6	87,079.6	973.2	86,228.4	121.6	256.4	85,794.4	999.6	87,201.2	85,538.0																							
INSOLUBLE SOLIDS	%	100%	0.8%	79.9%	0.0%	0.0%	0.0%	0.1%	0.0%	0.9%	0.1%																							
SOLUBLE SOLIDS	%	0.0%	7.4%	1.5%	7.4%	0.0%	0.0%	7.5%	0.0%	7.4%	7.5%																							
TEMPERATURE	°C	–	50	51	51	20	20	40	164	51	40																							
PRESSURE	atm	1.00	1.00	1.00	1.00	3.40	3.40	3.00	4.42	1.00	3.00																							
ETHANOL	kg/hr	–	17.2	–	17.2	–	–	17.2	–	17.2	17.2																							
WATER	kg/hr	–	79,213.0	178.8	79,034.8	–	–	78,214.0	999.6	79,213.6	78,214.0																							
GLUCOSE (SS)	kg/hr	–	722.4	1.6	720.8	–	–	722.4	–	722.4	722.4																							
XYLOSE (SS)	kg/hr	–	3,837.6	8.8	3,828.8	–	–	3,837.6	–	3,837.6	3,837.6																							
ACETIC ACID	kg/hr	–	124.8	0.4	124.4	–	–	124.8	–	124.8	124.8																							
CELLULOSE (IS)	kg/hr	–	65.6	65.2	0.4	–	–	65.6	–	65.6	65.6																							
OTHERS	kg/hr	285.6	3,099.0	718.4	2,502.0	121.6	256.4	2,812.8	–	3,220.0	2,556.4																							

DWG. No.	REFERENCE DRAWINGS

No.	DATE	REVISION	BY	CK'D	APPR.
0	01/10/00	FINAL	RML	PT	
A	09/04/99	PRELIMINARY	RML	DM	

ENGINEERING RECORD
DATE: 06/25/99
SCALE: NONE
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HOUSTON, TEXAS

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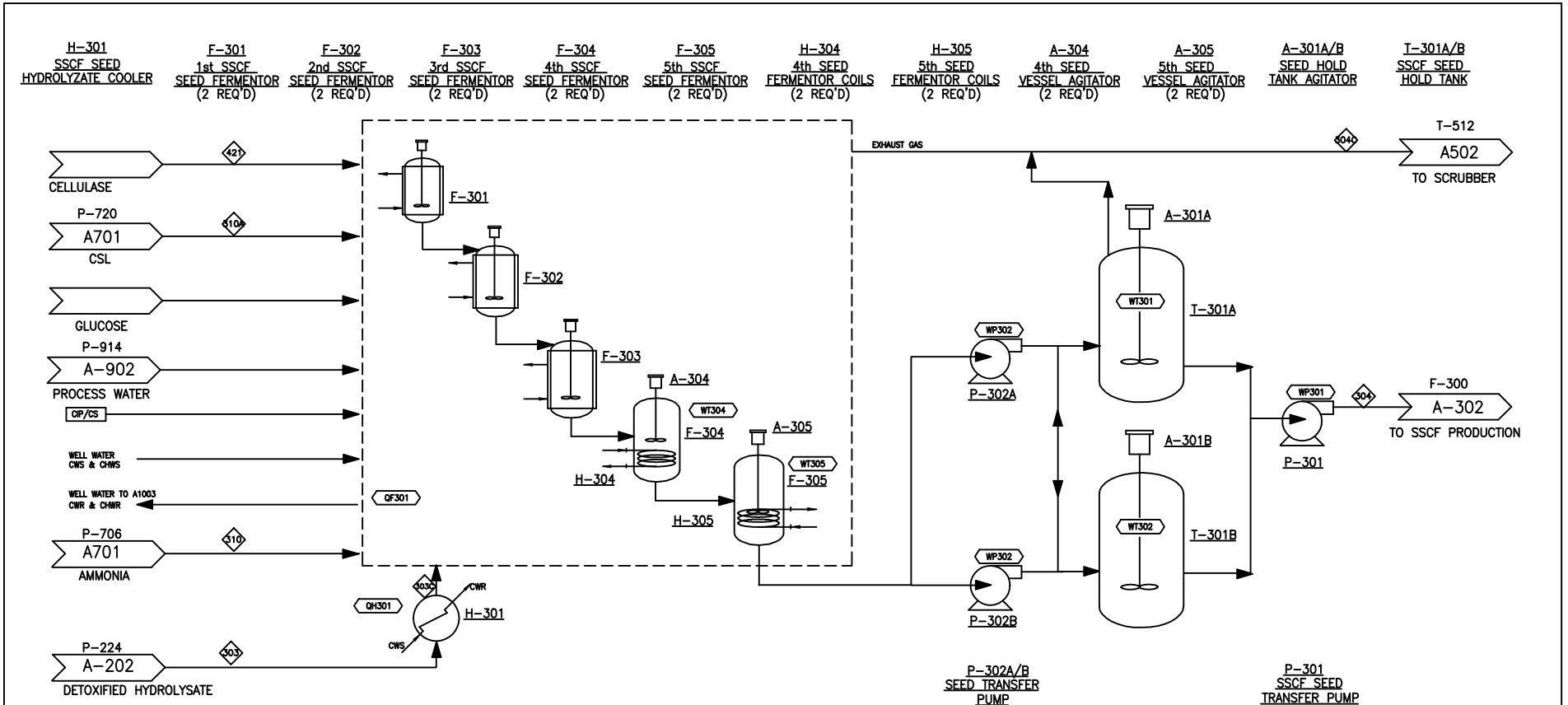
PROCESS FLOW DIAGRAM
SECTION A200
LIME ADDITION

PROJECT NUMBER	DRAWING NUMBER				
9827	D-200-N-A203	0			
Client	Size	Area	Type	Sequence	Rev.

D200NA203.DWG

01/10/00



STREAM NUMBER	UNITS	303	303C	304	304C	310	310A	421	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
STREAM NAME																																		
TOTAL FLOW	kg/hr	13,744.0	13,744.0	14,489.0	350.4	3.2	233.2	859.0																										
INSOLUBLE SOLIDS	%	16.2%	16.2%	14.5%	0.0%	0.0%	0.0%	10.2%																										
SOLUBLE SOLIDS	%	6.3%	6.3%	4.0%	0.0%	0.0%	100.0%	3.1%																										
TEMPERATURE	°C	59	30	30	30	35	35	28																										
PRESSURE	atm	1.00	1.00	1.00	1.00	1.00	1.00	1.66																										
ETHANOL	kg/hr	2.0	2.0	371.6	2.8	0.0	0.0	0.0																										
WATER	kg/hr	10,484.3	10,484.3	11,175.4	6.0	0.0	0.0	709.8																										
GLUCOSE (SS)	kg/hr	97.2	97.2	24.0	0.0	0.0	0.0	0.0																										
XYLOSE (SS)	kg/hr	516.0	516.0	51.6	0.0	0.0	0.0	0.0																										
ACETIC ACID	kg/hr	59.6	59.6	79.2	0.0	0.0	0.0	6.0																										
CELLULOSE (IS)	kg/hr	1,235.2	1,235.2	988.0	0.0	0.0	0.0	0.0																										
OTHERS	kg/hr	1,349.7	1,349.7	1,799.2	341.6	3.2	233.2	143.2																										

DWG. No.	REFERENCE DRAWINGS

No.	DATE	REVISION	BY	CK'D	APPR.
0	01/10/00	FINAL	RML	PT	
A	09/04/99	PRELIMINARY	RML	DM	

ENGINEERING RECORD
DATE: 07/07/99
SCALE: NONE
DRAWN BY: LANIER
CHECKED BY: DM
APPROVAL:
APPROVAL:

VOGELBUSCH USA, INC.
10810 OLD KATY ROAD, SUITE 107
HOUSTON, TEXAS

NREL
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Biotechnology Center For Fuels And Chemicals

NREL

PROCESS FLOW DIAGRAM
SECTION A300
SSCF SEED & PRODUCTION FERM.

PROJECT NUMBER	DRAWING NUMBER				
9827	D-300-N-A301	0			
Client	Size	Area	Type	Sequence	Rev.

D300NA301.DWG

01/10/00

H-302
SSCF HYDROLYZATE
COOLER
(3 REQ'D)

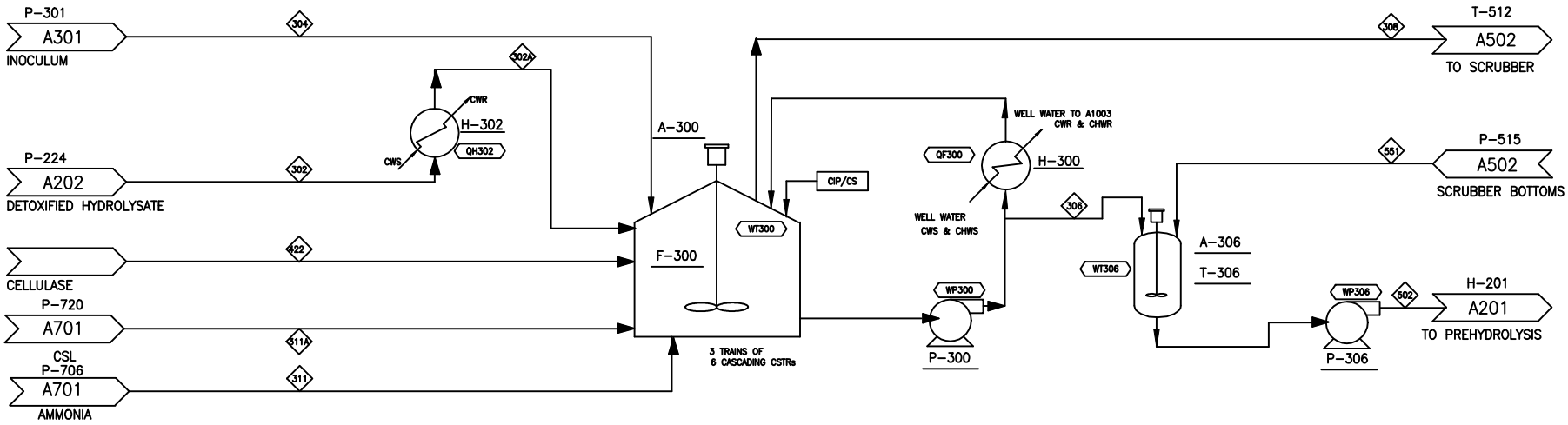
A-300
SSCF FERMENTOR
AGITATORS
(18 REQ'D)

F-300
SSCF FERMENTORS
(18 REQ'D)

H-300
FERMENTATION
COOLER
(18 REQ'D)

A-306
BEER SURGE
TANK AGITATOR

T-306
BEER STORAGE
TANK



P-300
SSCF RECIRCULATION
& TRANSFER PUMP
(18 REQ'D)

P-306
BEER TRANSFER
PUMP

STREAM NUMBER	UNITS	302	302A	304	306	308	311	311A	422	502	551	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
STREAM NAME																																		
TOTAL FLOW	kg/hr	131,560.6	131,560.6	14,489.0	147,347.9	7,220.2	54.9	408.0	8,055.6	153,081.3	5,733.3																							
INSOLUBLE SOLIDS	%	16.2%	16.2%	14.5%	9.0%	0.0%	0.0%	0.0%	10.2%	8.7%	0.0%																							
SOLUBLE SOLIDS	%	6.3%	6.3%	4.0%	3.1%	0.0%	0.0%	100.0%	3.1%	3.0%	0.0%																							
TEMPERATURE	°C	59	34	30	30	30	35	35	28	30	33																							
PRESSURE	atm	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.66	0.90	0.96																							
ETHANOL	kg/hr	18.8	18.8	371.6	7,713.7	111.3	0.0	0.0	0.9	7,906.2	192.5																							
WATER	kg/hr	100,357.6	100,357.6	11,175.4	117,208.4	122.2	0.0	0.0	6,627.9	122,680.8	5,472.5																							
GLUCOSE (SS)	kg/hr	928.8	928.8	24.0	92.9	0.0	0.0	0.0	0.0	92.9	0.0																							
XYLOSE (SS)	kg/hr	4,934.4	4,934.4	51.6	306.2	0.0	0.0	0.0	0.0	306.2	0.0																							
ACETIC ACID	kg/hr	570.7	570.7	79.2	1,073.9	0.4	0.0	0.0	59.1	1,074.8	0.8																							
CELLULOSE (IS)	kg/hr	11,823.1	11,823.1	988.0	1,537.3	0.0	0.0	0.0	0.0	1,537.3	0.0																							
OTHERS	kg/hr	12,927.1	12,927.1	1,799.2	19,415.5	6,986.2	54.9	408.0	1,367.7	19,483.0	67.5																							

DWG. No.	REFERENCE DRAWINGS

No.	DATE	REVISION	BY	CK'D	APPR.
0	01/10/00	FINAL	RML	PT	
A	09/04/99	PRELIMINARY	RML	DM	

ENGINEERING RECORD
DATE: 06/25/99
SCALE: NONE
DRAWN BY: LANIER
CHECKED BY: DM
APPROVAL:
APPROVAL:

VOGELBUSCH USA, INC.
10810 OLD KATY ROAD, SUITE 107
HOUSTON, TEXAS

NREL
NATIONAL RENEWABLE ENERGY LABORATORY
Biotechnology Center For Fuels And Chemicals

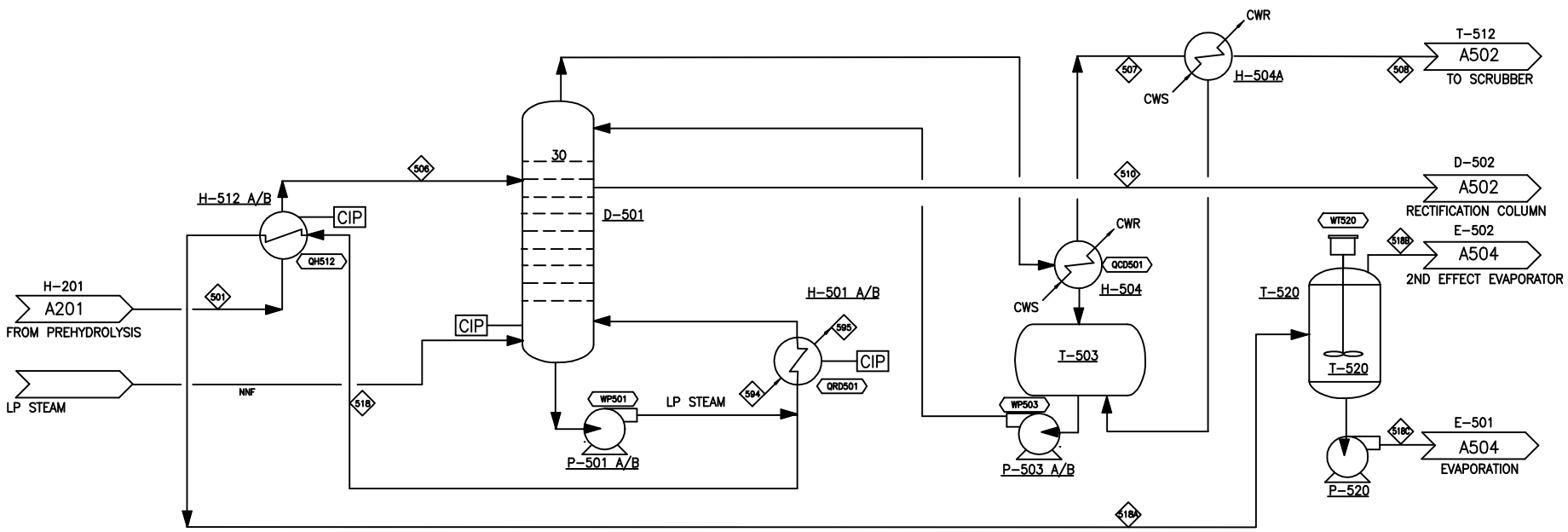
NREL

PROCESS FLOW DIAGRAM
SECTION A300
SSCF SEED & PRODUCTION FERM.

PROJECT NUMBER	DRAWING NUMBER				
9827	D-300-N-A302	0			
Client	Size	Area	Type	Sequence	Rev.

D300NA302.DWG

01/10/00



STREAM NUMBER	UNITS	501	506	507	508	510	518	518A	518B	518C	594	595	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
STREAM NAME																																		
TOTAL FLOW	kg/hr	153,081	153,081	330	241	25,583	127,258	127,258	2,035	125,223	27,250	27,250																						
INSOLUBLE SOLIDS	%	8.7%	8.7%	0.0%	0.0%	0.0%	10.5%	10.5%	0.0%	10.6%	0.0%	0.0%																						
SOLUBLE SOLIDS	%	3.0%	3.0%	0.0%	0.0%	0.0%	3.7%	3.7%	0.0%	3.7%	0.0%	0.0%																						
TEMPERATURE	°C	93.3	100	60	38	110	118	110	100	100	155	142																						
PRESSURE	atm	5.00	2.96	1.09	1.09	1.65	5.10	3.06	1.00	1.00	3.75	3.75																						
ETHANOL	kg/hr	7,906	7,906	97	26	7,867	13	13	2	11	0	0																						
WATER	kg/hr	122,681	122,681	20	4	17,357	105,321	105,321	2,001	103,320	27,250	27,250																						
GLUCOSE (SS)	kg/hr	93	93	0	0	0	93	93	0	93	0	0																						
XYLOSE (SS)	kg/hr	306	306	0	0	0	306	306	0	306	0	0																						
ACETIC ACID	kg/hr	1,704	1,704	0	0	165	908	908	20	889	0	0																						
CELLULOSE (IS)	kg/hr	1,535	1,535	0	0	0	1,535	1,535	0	1,535	0	0																						
OTHERS	kg/hr	19,486	19,486	213	211	194	19,082	19,082	12	19,069	0	0																						

DWG. No.	REFERENCE DRAWINGS

No.	DATE	REVISION	BY	CK'D	APPR.
0	01/10/00	FINAL	RML	PT	
A	09/04/99	PRELIMINARY	RML	DM	

ENGINEERING RECORD
DATE: 06/25/99
SCALE: NONE
DRAWN BY: LANIER
CHECKED BY: DM
APPROVAL:
APPROVAL:

VOGELBUSCH USA, INC.
10810 OLD KATY ROAD, SUITE 107
HOUSTON, TEXAS

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NATIONAL RENEWABLE ENERGY LABORATORY
Biotechnology Center For Fuels And Chemicals

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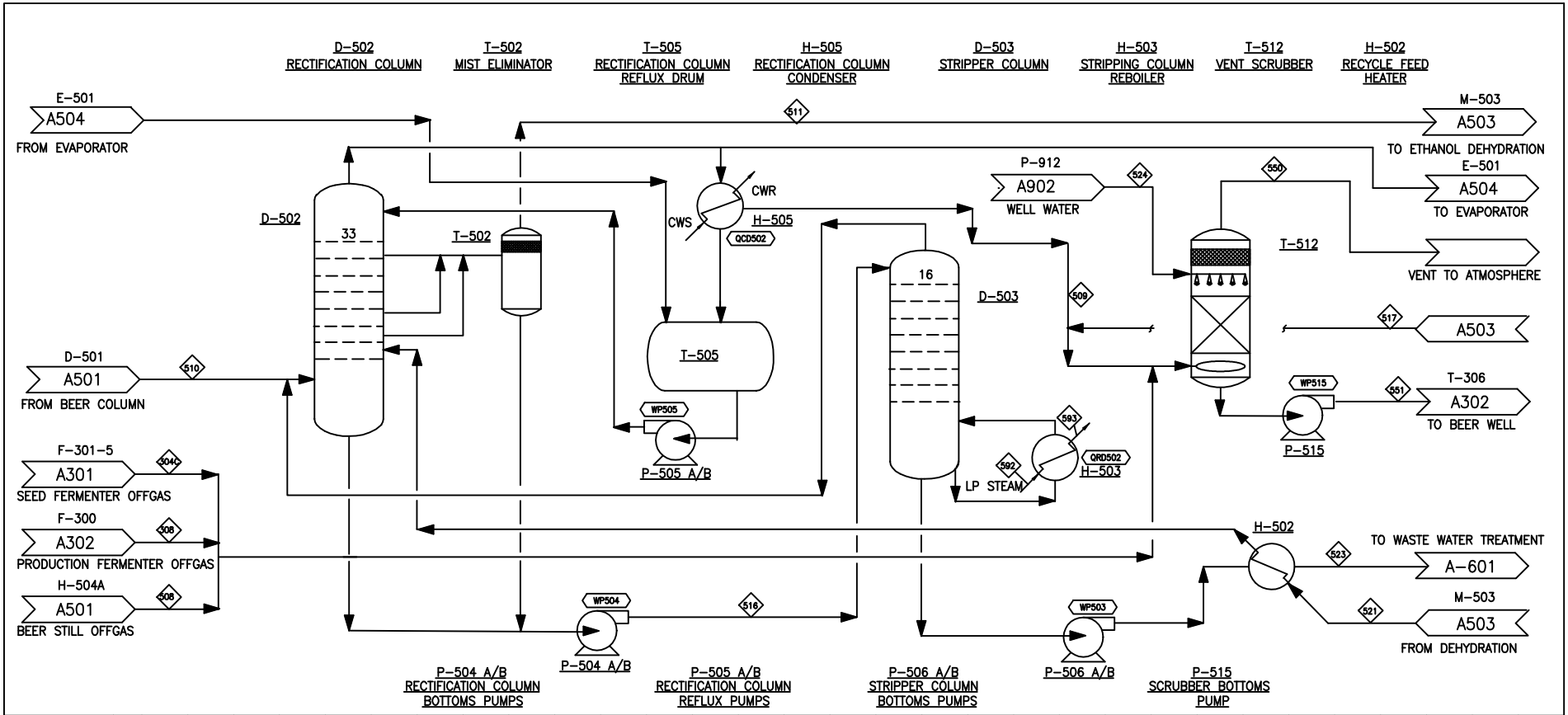
PROCESS FLOW DIAGRAM
SECTION A500
BEER DISTILLATION

PROJECT NUMBER	DRAWING NUMBER				
9827	D-500-N-A501				0
Client	Size	Area	Type	Sequence	Rev.

D500NA501.DWG

01/10/00



STREAM NUMBER	UNITS	304C	308	508	509	511	516	517	521	523	524	550	551	592	593	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
STREAM NAME																																	
TOTAL FLOW	kg/hr	350.4	7,220.2	241	60	10,374	21,328	21	2,470	17,622	5,410	7,513	5,733	3,500	3,500																		
INSOLUBLE SOLIDS	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%																		
SOLUBLE SOLIDS	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%																		
TEMPERATURE	°C	30	30	38	80	86	110	149	34	108	18	23	33	155	147																		
PRESSURE	atm	1.00	1.00	1.09	1.09	1.16	2.38	1.09	4.42	5.44	4.42	0.95	0.96	4.20	4.20																		
ETHANOL	kg/hr	3	111	26	54	9,375	883	0.3	1,564	2	0	1	193	0	0																		
WATER	kg/hr	6	122	4	4	884	20,110	20	887	17,356	5,410	93	5,473	3,500	3,500																		
GLUCOSE (SS)	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0																		
XYLOSE (SS)	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0																		
ACETIC ACID	kg/hr	0	0	0	0	2	199	0	0	163	0	0	0	0	0																		
CELLULOSE (IS)	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0																		
OTHERS	kg/hr	342	6,930	211	2	113	135	1	19	101	0	7,419	68	0	0																		

DWG. No.	REFERENCE DRAWINGS

No.	DATE	REVISION	BY	CK'D	APPR.
0	01/10/00	FINAL	RML	PT	
A	09/04/99	PRELIMINARY	RML	DM	

ENGINEERING RECORD
DATE: 06/25/99
SCALE: NONE
DRAWN BY: LANIER
CHECKED BY: DM
APPROVAL:
APPROVAL:

VOGELBUSCH USA, INC.
10810 OLD KATY ROAD, SUITE 107
HOUSTON, TEXAS

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Biotechnology Center For Fuels And Chemicals

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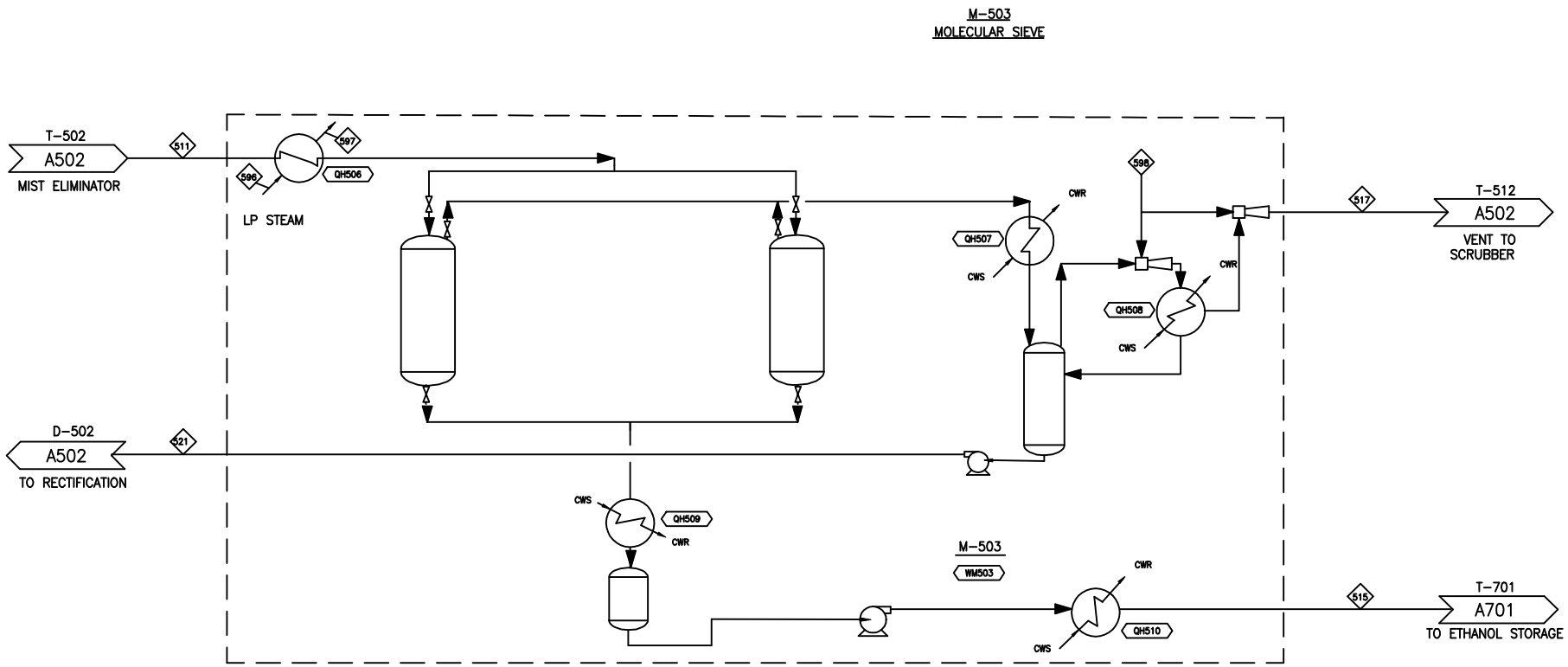
PROCESS FLOW DIAGRAM
SECTION A500
RECTIFICATION DISTILLATION

PROJECT NUMBER	DRAWING NUMBER				
9827	D-500-N-A502				0
Client	Size	Area	Type	Sequence	Rev.

D500NA502.DWG

01/10/00



STREAM NUMBER	UNITS	515	517	521	596	597	598	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
STREAM NAME																																			
TOTAL FLOW	kg/hr	7,945	21	2,470	310	310	63																												
INSOLUBLE SOLIDS	%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%																												
SOLUBLE SOLIDS	%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%																												
TEMPERATURE	°C	35	149	34	170	143	186																												
PRESSURE	atm	2.00	1.09	2.00	3.7	3.7	11.2																												
ETHANOL	kg/hr	7,811	0.3	1,564	0	0	0																												
WATER	kg/hr	40	20	887	310	310	63																												
GLUCOSE (SS)	kg/hr	0	0	0	0	0	0																												
XYLOSE (SS)	kg/hr	0	0	0	0	0	0																												
ACETIC ACID	kg/hr	2	0	0	0	0	0																												
CELLULOSE (IS)	kg/hr	0	0	0	0	0	0																												
OTHERS	kg/hr	92	1	19	0	0	0																												

DWG. No.	REFERENCE DRAWINGS

No.	DATE	REVISION	BY	CK'D	APPR.
0	01/10/00	FINAL	RML	PT	
A	09/04/99	PRELIMINARY	RML	DM	

ENGINEERING RECORD
DATE: 06/25/99
SCALE: NONE
DRAWN BY: LANIER
CHECKED BY: DM
APPROVAL:
APPROVAL:

VOGELBUSCH USA, INC.
10810 OLD KATY ROAD, SUITE 107
HOUSTON, TEXAS

NATIONAL RENEWABLE ENERGY LABORATORY
Biotechnology Center For Fuels And Chemicals

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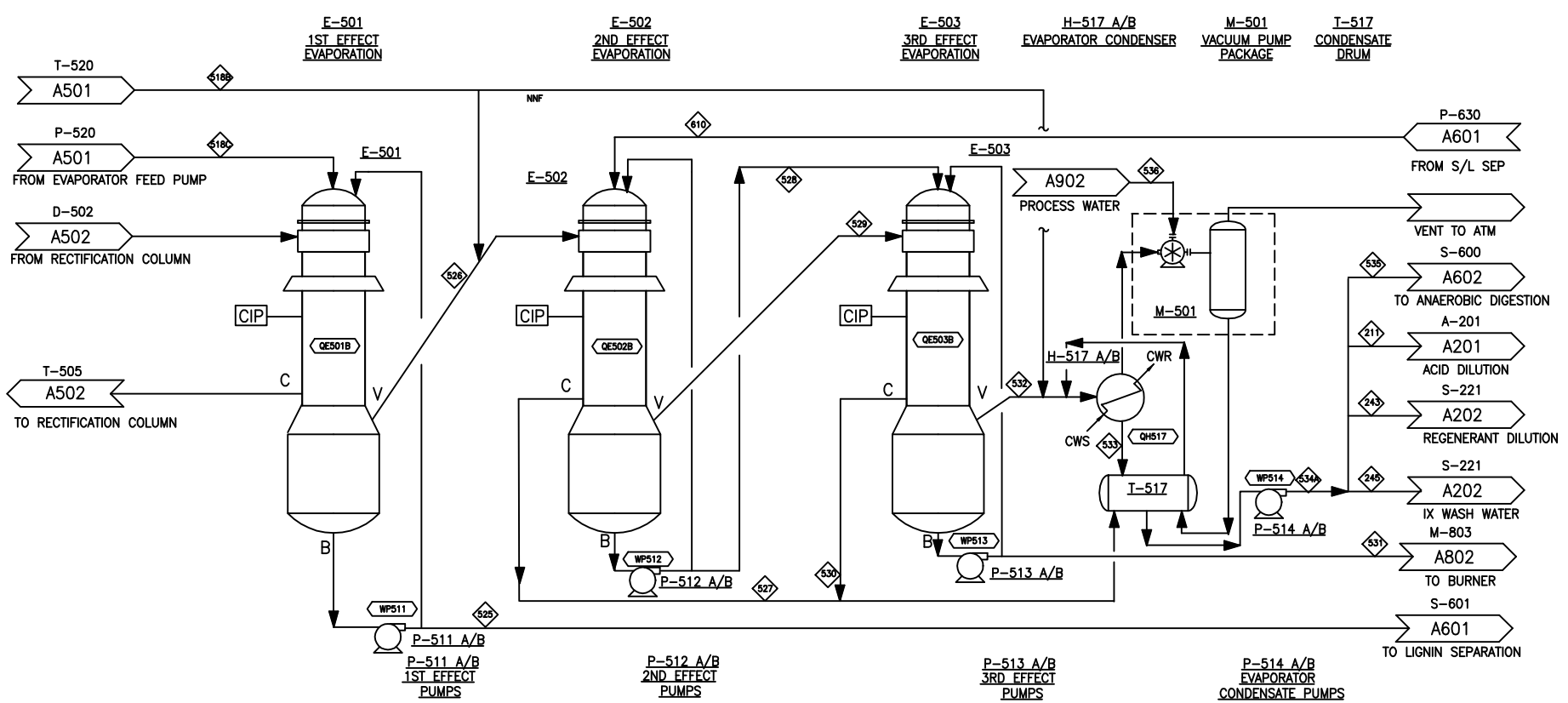
PROCESS FLOW DIAGRAM
SECTION A500
ETHANOL DEHYDRATION

PROJECT NUMBER	DRAWING NUMBER				
9827	D-500-N-A503	0			
Client	Size	Area	Type	Sequence	Rev.

D500NA503.DWG

01/10/00



STREAM NUMBER	UNITS	211	243	245	525	526	527	528	529	530	531	532	533	534	535	536
STREAM NAME																
TOTAL FLOW	kg/hr	28,310.6	26,331.2	11,944.8	101,211	24,012	26,047	32,454	23,046	23,046	9,276	23,178	24,472	73,177.0	6,590.4	906.0
INSOLUBLE SOLIDS	%	0.0%	0.0%	0.0%	13.2%	0.0%	0.0%	1.8%	0.0%	0.0%	6.1%	0.0%	0.0%	0.0%	0.0%	0.0%
SOLUBLE SOLIDS	%	0.3%	0.3%	0.3%	4.6%	0.0%	0.0%	7.4%	0.0%	0.0%	25.9%	0.0%	0.0%	0.3%	0.3%	0.0%
TEMPERATURE	°C	54	54	54	76	76	75	69	69	68	63	63	47	54	54	13
PRESSURE	atm	3.06	3.06	3.06	0.39	0.39	0.39	0.29	0.29	0.29	2.23	0.19	0.12	3.06	3.06	1.00
ETHANOL	kg/hr	4.6	4.3	2.0	2	9	10	0.0	1	1	0.0	0.0	3	12.0	1.1	0.0
WATER	kg/hr	27,818.5	25,873.5	11,737.2	79,903	23,418	25,418	27,779	22,649	22,649	4,848	23,931	24,133	71,905.0	6,475.8	906.0
GLUCOSE (SS)	kg/hr	0.0	0.0	0.0	93	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
XYLOSE (SS)	kg/hr	0.0	0.0	0.0	306	0.0	0.0	193	0.0	0.0	193	0.0	0.0	0.0	0.0	0.0
ACETIC ACID	kg/hr	250.3	232.8	105.6	636	252	272	187	214	214	27	160	174	647.0	58.3	0.0
CELLULOSE (IS)	kg/hr	0.0	0.0	0.0	1,535	0.0	0.0	26	0.0	0.0	26	0.0	0.0	0.0	0.0	0.0
OTHERS	kg/hr	237.2	220.6	100.1	18,736	334	346	4,269	181	181	4,182	86	162	613.0	55.2	0.0

DWG. No.	REFERENCE DRAWINGS

No.	DATE	REVISION	BY	CK'D	APPR.
0	01/10/00	FINAL	RML	PT	
A	09/04/99	PRELIMINARY	RML	DM	

ENGINEERING RECORD
DATE: 06/25/99
SCALE: NONE
DRAWN BY: LANIER
CHECKED BY: DM
APPROVAL:
APPROVAL:

VOGELBUSCH USA, INC.
10810 OLD KATY ROAD, SUITE 107
HOUSTON, TEXAS

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Biotechnology Center For Fuels And Chemicals

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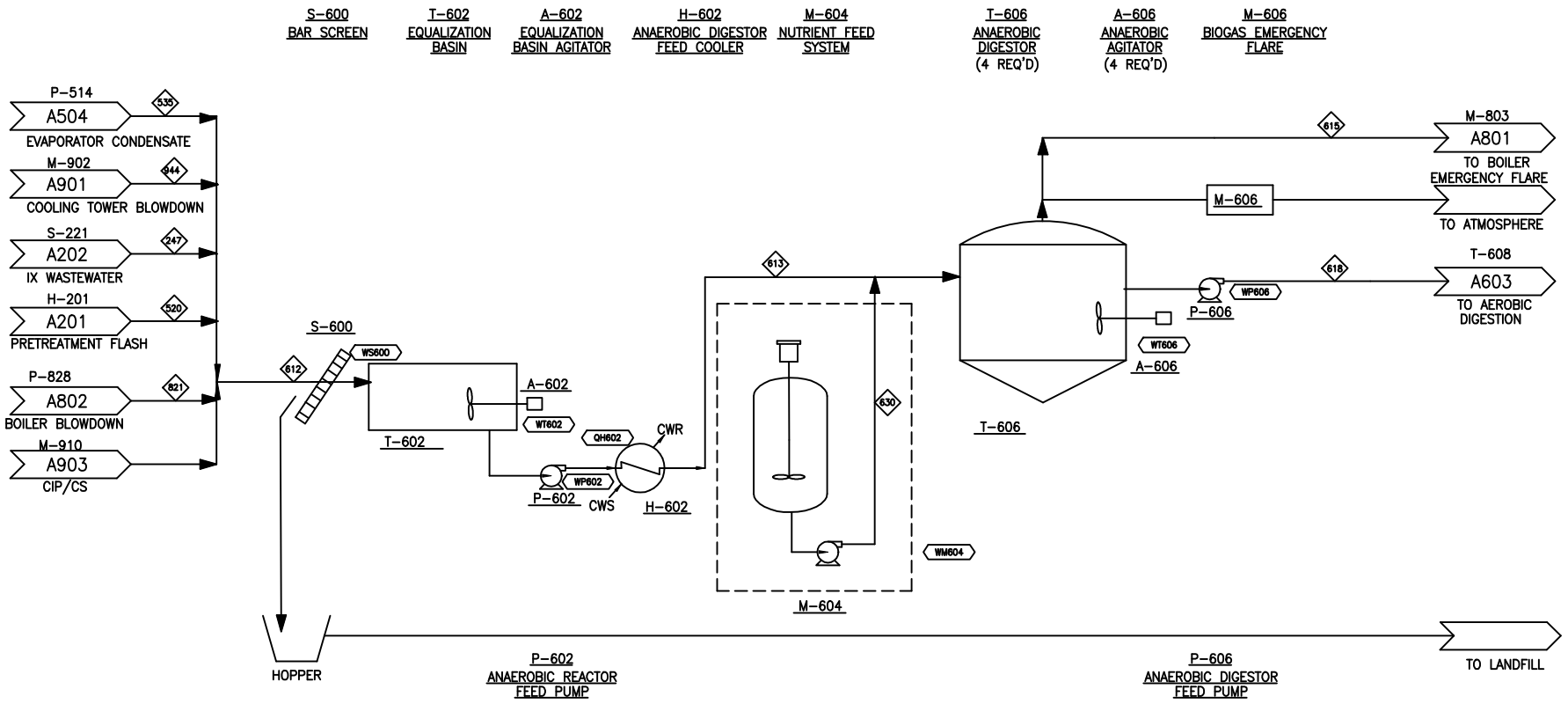
PROCESS FLOW DIAGRAM
SECTION A500
EVAPORATOR

PROJECT NUMBER	DRAWING NUMBER				
9827	D-500-N-A504	0			
Client	Size	Area	Type	Sequence	Rev.

D500NA504

01/10/00



STREAM NUMBER	UNITS	247	520	535	612	613	615	618	630	821	944	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
STREAM NAME																																	
TOTAL FLOW	kg/hr	37,056.4	18,079.14	6,590.4	71,738.4	71,738.4	1,078.6	70,777.6	92.0	2,910.0	7,128.0																						
INSOLUBLE SOLIDS	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%																						
SOLUBLE SOLIDS	%	4.9%	0.1%	0.3%	2.6%	2.6%	0.0%	0.2%	0.0%	0.0%	0.0%																						
TEMPERATURE	°C	40	100	54	79	35	35	35	20	309	28																						
PRESSURE	atm	3.00	1.00	3.06	2.00	2.00	1.00	1.00	1.00	96.26	1.00																						
ETHANOL	kg/hr	0.0	11.6	1.1	16.8	16.8	0.0	1.2	0.0	0.0	0.0																						
WATER	kg/hr	35,157.2	17,528.8	6,475.8	69,239.2	69,239.2	46.0	70,270.0	0.0	2,910.0	7,128.0																						
GLUCOSE (SS)	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0																						
XYLOSE (SS)	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0																						
ACETIC ACID	kg/hr	0.0	106.0	58.4	134.4	134.4	0.0	9.6	0.0	0.0	0.0																						
CELLULOSE (IS)	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0																						
OTHERS	kg/hr	1,899.2	407.2	55.2	2,348.0	2,348.0	1,006.8	496.8	92	0.0	0.0																						

DWG. No.	REFERENCE DRAWINGS

No.	DATE	REVISION	BY	CK'D	APPR.
0	01/10/00	FINAL	RML	PT	
A	09/04/99	PRELIMINARY	RML	DM	

ENGINEERING RECORD
DATE: 06/25/99
SCALE: NONE
DRAWN BY: LANIER
CHECKED BY: DM
APPROVAL:
APPROVAL:

VOGELBUSCH USA, INC.
10810 OLD KATY ROAD, SUITE 107
HOUSTON, TEXAS

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Biotechnology Center For Fuels And Chemicals

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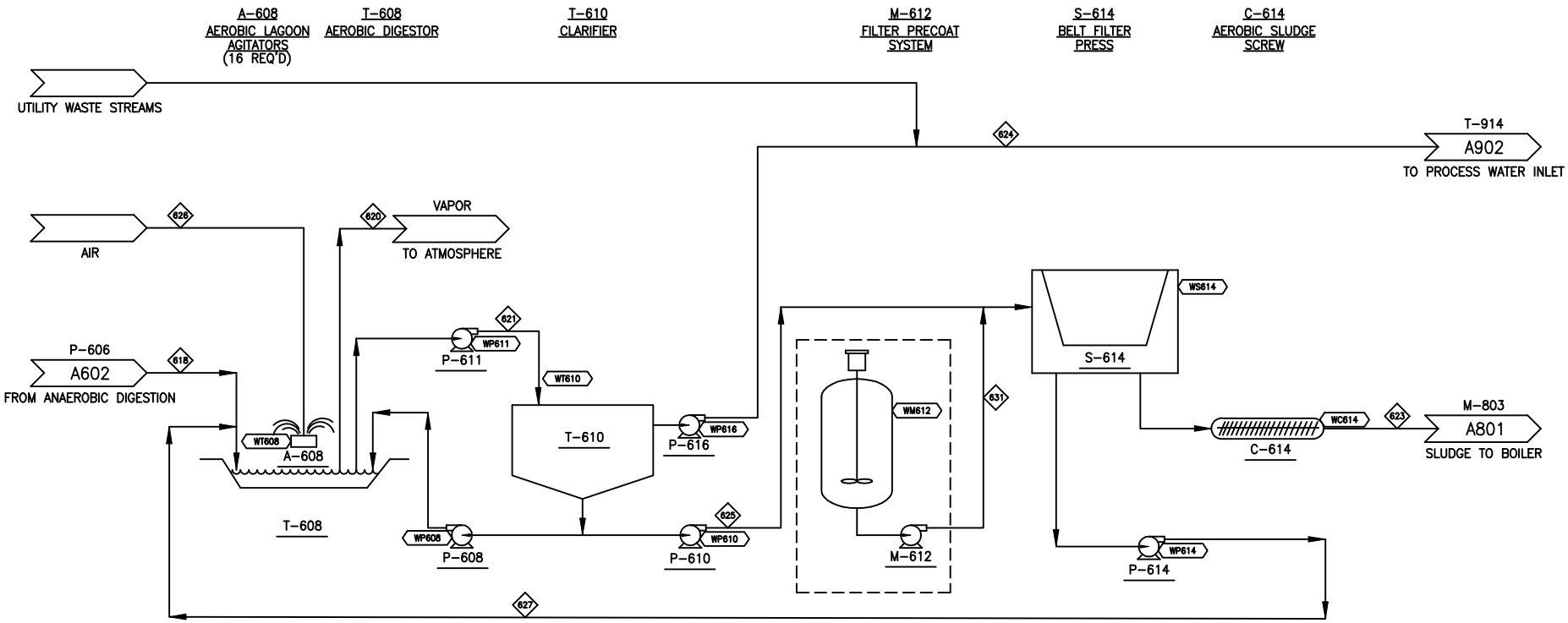
PROCESS FLOW DIAGRAM
SECTION A600
ANAEROBIC DIGESTION

PROJECT NUMBER	DRAWING NUMBER				
9827	D-600-N-A602				0
Client	Size	Area	Type	Sequence	Rev.

D600NA602.DWG

01/10/00



STREAM NUMBER	UNITS	618	620	821	823	824	825	826	627	631	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
STREAM NAME																																		
TOTAL FLOW	kg/hr	70,777.6	62,411.2	71,466.8	367.2	69,261.6	2,205.2	61,262.0	1,838.4	0.4																								
INSOLUBLE SOLIDS	%	0.1%	0.0%	0.2%	29.9%	0.0%	5.0%	0.0%	0.0%	0.0%																								
SOLUBLE SOLIDS	%	0.2%	0.0%	0.1%	0.0%	0.1%	0.1%	0.0%	0.1%	0.0%																								
TEMPERATURE	°C	35	21	21	21	21	21	20	21	20																								
PRESSURE	atm	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00																								
ETHANOL	kg/hr	1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0																								
WATER	kg/hr	70,270.0	972.0	71,192.4	256.4	69,102.0	2,090.4	0.0	1,833.6	0.0																								
GLUCOSE (SS)	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0																								
XYLOSE (SS)	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0																								
ACETIC ACID	kg/hr	9.6	0.0	0.8	0.0	0.8	0.0	0.0	0.0	0.0																								
CELLULOSE (IS)	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0																								
OTHERS	kg/hr	498.8	61,439.2	273.6	110.8	158.8	114.8	61,262.0	4.8	0.4																								

DWG. No.	REFERENCE DRAWINGS

No.	DATE	REVISION	BY	CK'D	APPR.
0	01/10/00	FINAL	RML	PT	
A	09/04/99	PRELIMINARY	RML	DM	

ENGINEERING RECORD	
DATE:	06/25/99
SCALE:	NONE
DRAWN BY:	LANIER
CHECKED BY:	DM
APPROVAL:	
APPROVAL:	

VOGELBUSCH USA, INC.
10810 OLD KATY ROAD, SUITE 107
HOUSTON, TEXAS

NATIONAL RENEWABLE ENERGY LABORATORY
Biotechnology Center For Fuels And Chemicals

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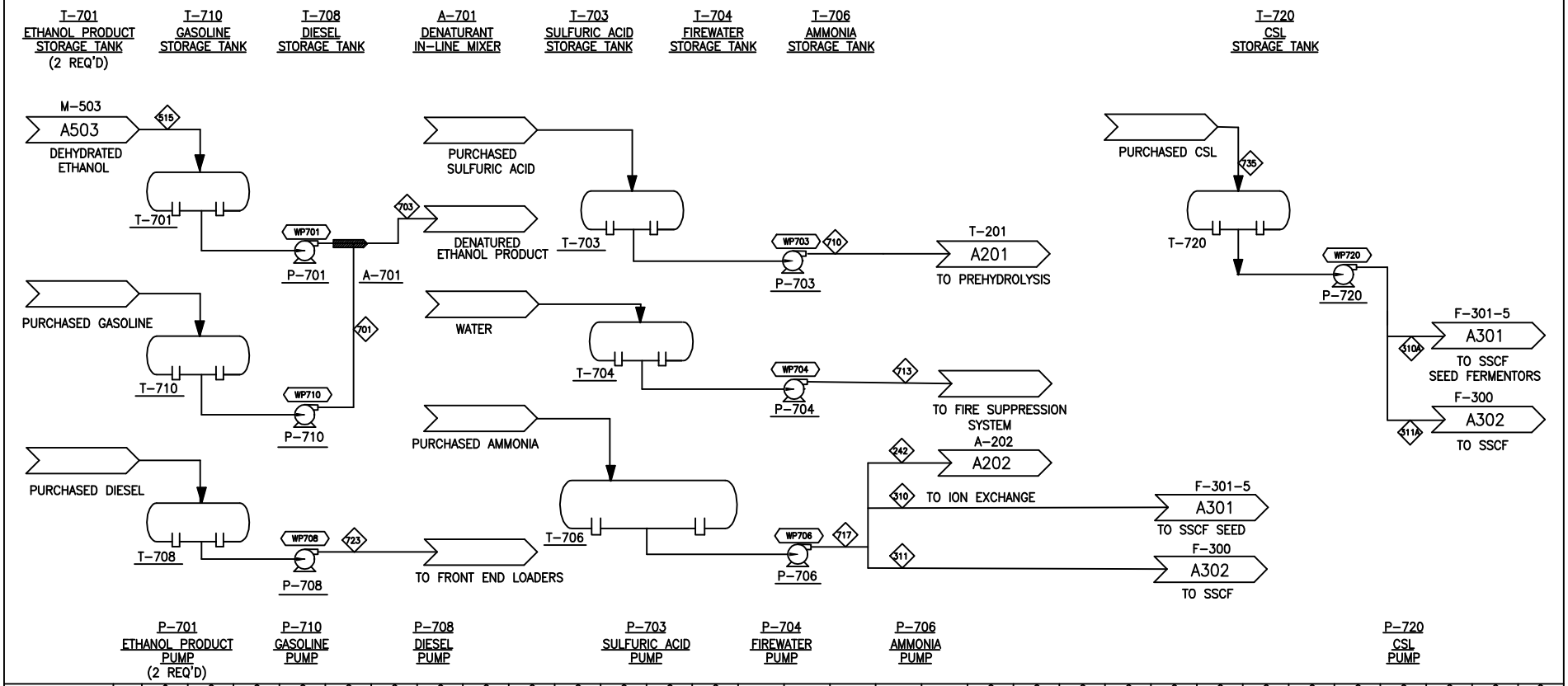
PROCESS FLOW DIAGRAM
SECTION A600
AEROBIC DIGESTION

PROJECT NUMBER	DRAWING NUMBER				
9827	D-600-N-A603	0			
Client	Size	Area	Type	Sequence	Rev.

D600NA603.DWG

01/10/00



STREAM NUMBER	UNITS	242	310	104	311	111A	515	701	703	710	713	717	723	735						◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇
STREAM NAME																																
TOTAL FLOW	kg/hr	451.2	3.2	233.6	51.6	384	7,945	380	8,325	747.2	2,731.2	563.2	177.2	791.6																		
INSOLUBLE SOLIDS	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%																		
SOLUBLE SOLIDS	%	0.0%	0.0%	0.0%	*8.6%	*8.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%																		
TEMPERATURE	°C	20	35	35	35	35	35	20	34	20	20	20	20	20																		
PRESSURE	atm	17.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	17.00	1.00	1.00																		
ETHANOL	kg/hr	0.0	0.0	0.0	0.0	0.0	7,811	0.0	7,811	0.0	0.0	0.0	0.0	0.0																		
WATER	kg/hr	0.0	0.0	0.0	46.6	346.8	40	0.0	40	0.0	2,731.2	0.0	0.0	0.0																		
GLUCOSE (SS)	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0																		
XYLOSE (SS)	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0																		
ACETIC ACID	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0																		
CELLULOSE (IS)	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0																		
OTHERS	kg/hr	451.2	3.2	233.6	5.0	37.2	92	380	472	747.2	0	563.2	177.2	791.6																		

* TOTAL SOLIDS FROM CHIEF DESIGN DATA

DWG. No.	REFERENCE DRAWINGS

No.	DATE	REVISION	BY	CK'D	APPR.
0	01/10/00	FINAL	RML	PT	
A	09/04/99	PRELIMINARY	RML	DM	

ENGINEERING RECORD
DATE: 06/25/99
SCALE: NONE
DRAWN BY: LANIER
CHECKED BY: DM
APPROVAL:
APPROVAL:

VOGELBUSCH USA, INC.
10810 OLD KATY ROAD, SUITE 107
HOUSTON, TEXAS

NATIONAL RENEWABLE ENERGY LABORATORY
Biotechnology Center For Fuels And Chemicals

NREL

PROCESS FLOW DIAGRAM
SECTION A700
STORAGE

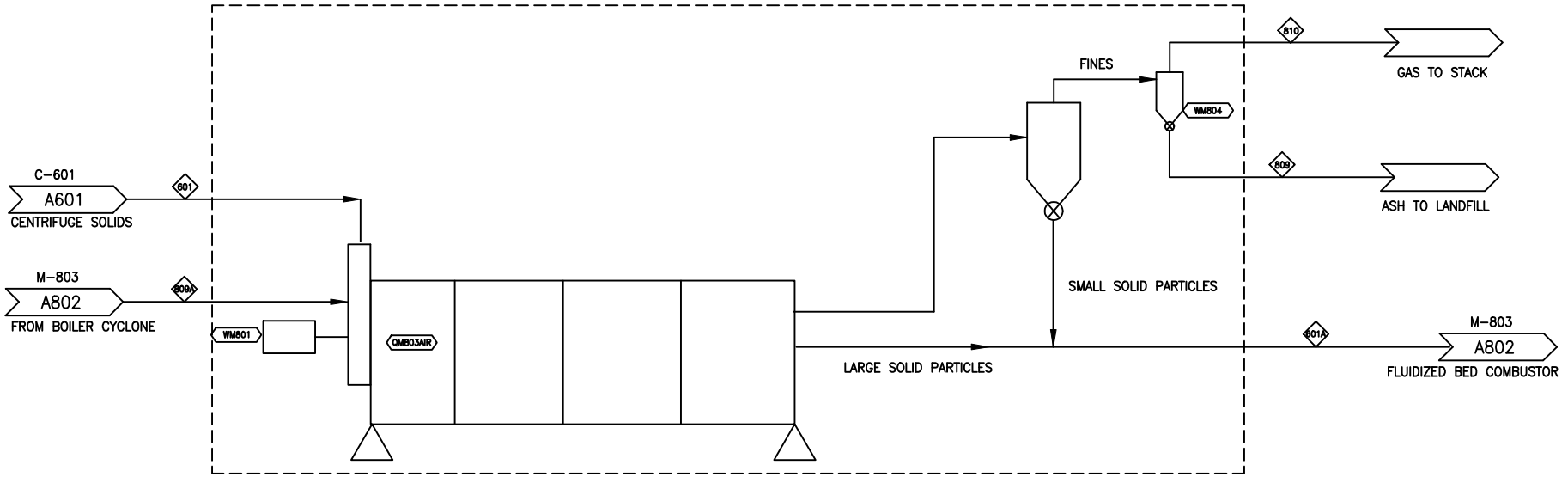
PROJECT NUMBER	DRAWING NUMBER				
9827	D-700-N-A701	0			
Client	Size	Area	Type	Sequence	Rev.

D700NA701.DWG

01/10/00

M-801

SOLID FEED DRYER BAGHOUSE



M-801

STREAM NUMBER	UNITS	801	801A	809	809A	810	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
STREAM NAME																																	
TOTAL FLOW	kg/hr	35,315.0	29,472.3	442.4	239,162.0	247,562.5																											
INSOLUBLE SOLIDS	%	35.8%	40.8%	100%	0.2%	0.8%																											
SOLUBLE SOLIDS	%	5.1%	5.0%	0.0%	0.3%	0.5%																											
TEMPERATURE	°C	40	101	167	167	167																											
PRESSURE	atm	3.20	1.00	1.0	0.97	0.97																											
ETHANOL	kg/hr	1.0	0.4	0.0	3.6	4.2																											
WATER	kg/hr	20,029.0	13,563.0	0.0	48,551.6	67,224.4																											
GLUCOSE (SS)	kg/hr	93.0	93.0	0.0	0.8	0.8																											
XYLOSE (SS)	kg/hr	77.0	77.0	0.0	2.4	2.4																											
ACETIC ACID	kg/hr	160.0	140.4	0.0	36.4	56.0																											
CELLULOSE (IS)	kg/hr	1,503.5	1,503.5	14.4	14.4	0.0																											
OTHERS	kg/hr	13,451.5	11,095.0	427.8	190,552.8	180,274.7																											

DWG. No.	REFERENCE DRAWINGS

No.	DATE	REVISION	BY	CK'D	APPR.
0	01/10/00	FINAL	RML	PT	
A	09/04/99	PRELIMINARY	RML	DM	

ENGINEERING RECORD
DATE: 06/22/99
SCALE: NONE
DRAWN BY: LANIER
CHECKED BY: DM
APPROVAL:
APPROVAL:

VOGELBUSCH USA, INC.
10810 OLD KATY ROAD, SUITE 107
HOUSTON, TEXAS

NREL NATIONAL RENEWABLE ENERGY LABORATORY
Biotechnology Center For Fuels And Chemicals

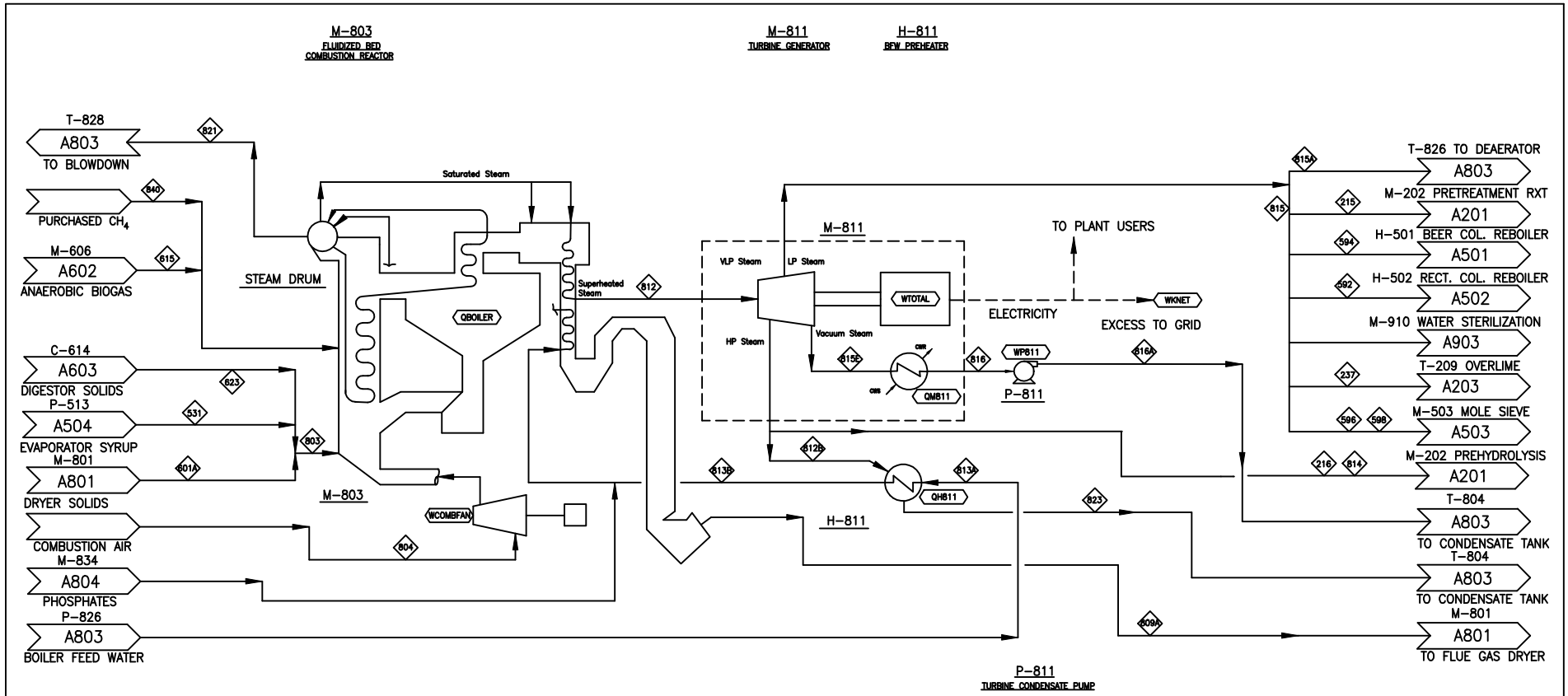
NREL

PROCESS FLOW DIAGRAM
SECTION A800
BOILER FEED DRYING

PROJECT NUMBER	DRAWING NUMBER				
9827	D-800-N-A801	0			
Client	Size	Area	Type	Sequence	Rev.

D800NA801.DWG

01/10/00



STREAM NUMBER	UNITS	531	601A	615	823	803	804	804A	812	812B	813A	813B	814	815	815A	815E	816	816A	821	823	840	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇
STREAM NAME																																	
TOTAL FLOW	kg/hr	9,276.0	29,472.3	1,078.6	367.2	36,115.5	188,683.2	239,162.0	94,085.2	7,265.6	97,000.4	97,000.4	17,838.4	32,480.0	10,368.4	22,204.0	22,204.0	22,204.0	2,910.0	7,265.6	0												
INSOLUBLE SOLIDS	%	6.1%	40.8%	0.0%	29.9%	31.8%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%												
SOLUBLE SOLIDS	%	25.9%	5.0%	0.0%	0.0%	10.3%	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%												
TEMPERATURE	°C	63	101	35	21	86	24	167	510	268	139	177	268	164	164	46	46	46	309	190	25												
PRESSURE	atm	2.23	1.00	1.00	1.00	1.00	1.00	0.97	86.06	13.00	98.31	97.63	13.00	4.42	4.42	0.10	0.10	4.20	96.26	12.32	1.00												
ETHANOL	kg/hr	0.0	0.4	0.0	0.0	0.4	0.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
WATER	kg/hr	4,848.0	13,563.0	47.1	256.4	18,667.4	2,452.8	48,551.6	94,085.2	7,265.6	97,000.4	97,000.4	17,838.4	32,480.0	10,368.4	22,204.0	22,204.0	22,204.0	2,910.0	7,265.6	0.0												
GLUCOSE (SS)	kg/hr	0.0	93.0	0.0	0.0	93.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
XYLOSE (SS)	kg/hr	193.0	77.0	0.0	0.0	270.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
ACETIC ACID	kg/hr	27.0	140.4	0.0	0.0	167.4	0.0	36.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
CELLULOSE (IS)	kg/hr	26.0	1,503.5	0.0	0.0	1,529.5	0.0	14.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
OTHERS	kg/hr	4,182.0	11,095.0	1,031.5	110.8	15,387.8	186,230.4	190,552.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												

DWG. No.	REFERENCE DRAWINGS

No.	DATE	REVISION	BY	CK'D	APPR.
0	01/10/00	FINAL	RML	PT	
A	09/04/99	PRELIMINARY	RML	DM	

ENGINEERING RECORD
DATE: 06/22/99
SCALE: NONE
DRAWN BY: LANIER
CHECKED BY: DM
APPROVAL:
APPROVAL:

VOGELBUSCH USA, INC.
10810 OLD KATY ROAD, SUITE 107
HOUSTON, TEXAS

NATIONAL RENEWABLE ENERGY LABORATORY
Biotechnology Center For Fuels And Chemicals

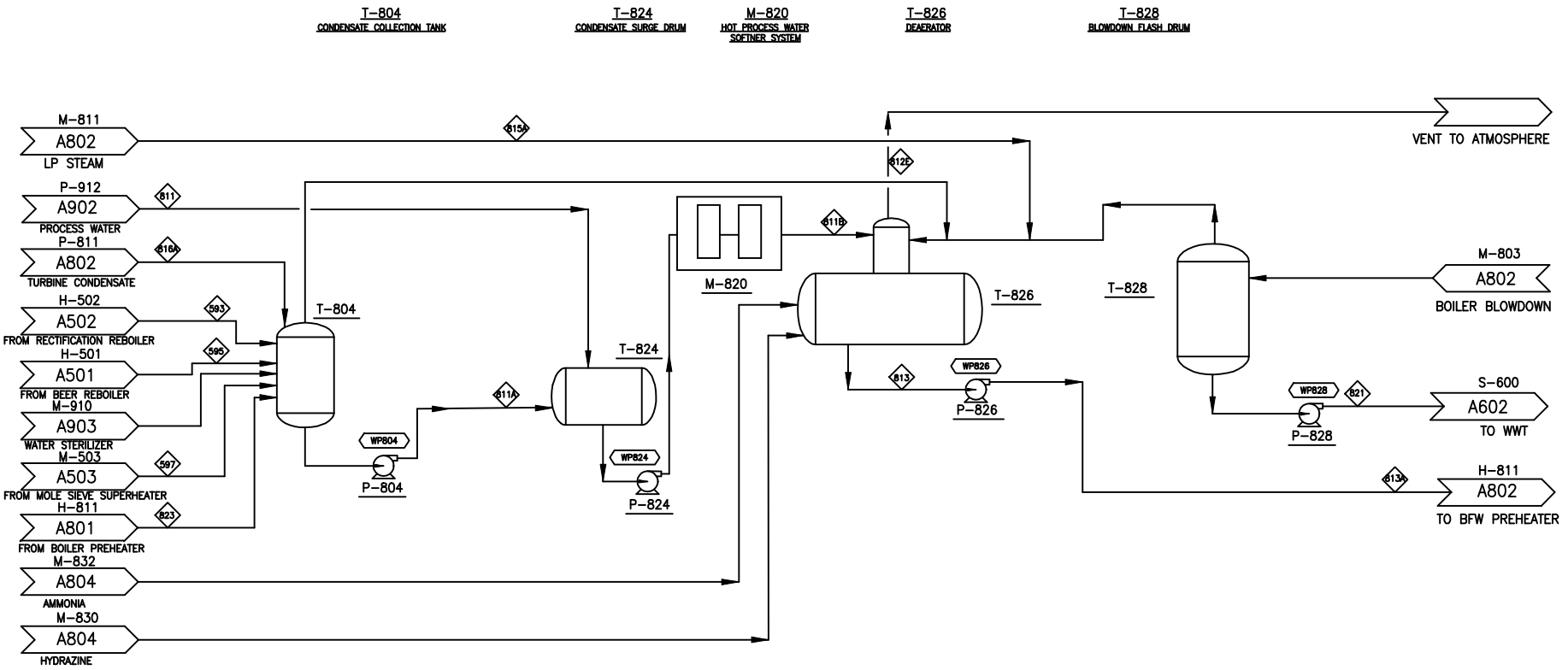
NREL

PROCESS FLOW DIAGRAM
SECTION A800
COMBUSTER AND TURBO GENERATOR

PROJECT NUMBER	DRAWING NUMBER				
9827	D-800-N-A802				0
Client	Size	Area	Type	Sequence	Rev.

D800N1802.DWG

01/10/00



STREAM NUMBER	UNITS	593	595	597	811	811A	811B	812E	813	813A	815A	816A	821	823	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
STREAM NAME																																	
TOTAL FLOW	kg/hr	3,500.0	27,250.0	310.0	28,532.4	58,099.6	86,632.0	0.0	97,000.4	97,000.4	10,368.4	22,204.0	2,910.0	7,265.6																			
INSOLUBLE SOLIDS	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%																			
SOLUBLE SOLIDS	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%																			
TEMPERATURE	°C	148	148	148	26	99	75	0.0	137	139	164	46	309	190																			
PRESSURE	atm	4.42	4.42	4.42	3.40	1.70	3.40	3.30	3.30	98.31	4.42	4.20	96.26	12.32																			
ETHANOL	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0																			
WATER	kg/hr	3,500.0	27,250.0	310.0	28,532.4	58,099.6	86,632.0	0.0	97,000.4	97,000.4	10,368.4	22,204.0	2,910.0	7,265.6																			
GLUCOSE (SS)	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0																			
XYLOSE (SS)	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0																			
ACETIC ACID	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0																			
CELLULOSE (IS)	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0																			
OTHERS	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0																			

DWG. No.	REFERENCE DRAWINGS

No.	DATE	REVISION	BY	CK'D	APPR.
0	01/10/00	FINAL	RML	PT	
A	09/04/99	PRELIMINARY	RML	DM	

ENGINEERING RECORD
DATE: 06/22/99
SCALE: NONE
DRAWN BY: LANIER
CHECKED BY: DM
APPROVAL:
APPROVAL:

VOGELBUSCH USA, INC.
10810 OLD KATY ROAD, SUITE 107
HOUSTON, TEXAS

NATIONAL RENEWABLE ENERGY LABORATORY
Biotechnology Center For Fuels And Chemicals

NREL

PROCESS FLOW DIAGRAM
SECTION A800
BOILER FEED WATER PREPARATION

PROJECT NUMBER	DRAWING NUMBER				
9827	D-800-N-A803				0
Client	Size	Area	Type	Sequence	Rev.

D800NA803.DWG

01/10/00

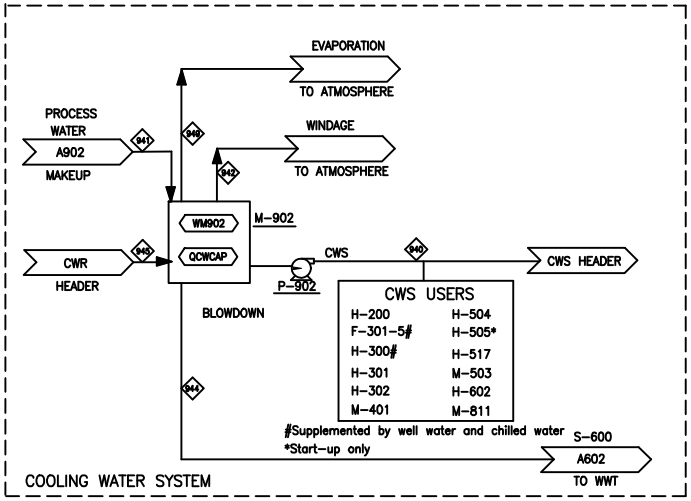
M-902
COOLING TOWER
SYSTEM

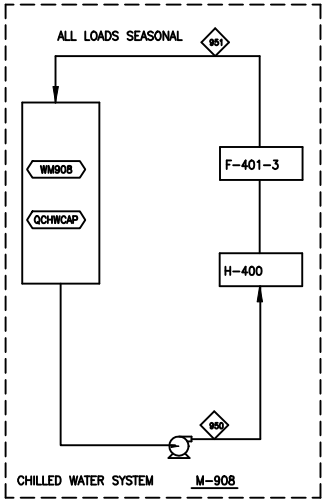
M-908
CHILLED WATER
SYSTEM

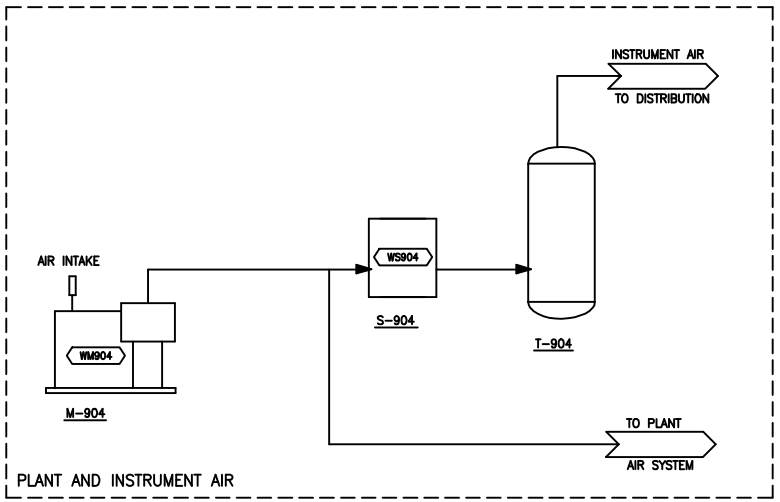
M-904
PLANT AIR
COMPRESSOR

S-904
INSTRUMENT
AIR DRYER

T-904
INSTRUMENT
AIR RECEIVER







P-902
COOLING WATER
PUMP

STREAM NUMBER	UNITS	940	941	942	944	945	949	950	951	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
STREAM NAME																											
TOTAL FLOW	kg/hr	5,536,280.0	78,409.6	4,606.4	7,128.0	5,536,280.0	66,675.2	1,951,536.0	1,951,536.0																		
INSOLUBLE SOLIDS	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%																		
SOLUBLE SOLIDS	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%																		
TEMPERATURE	°C	37	28	28	28	28	28	4	8																		
PRESSURE	atm	4.08	1.00	1.00	1.00	4.08	0.04	4.08	4.08																		
ETHANOL	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0																		
WATER	kg/hr	5,536,280.0	78,409.6	4,606.4	7,128.0	5,536,280.0	66,675.2	1,951,536.0	1,951,536.0																		
GLUCOSE (SS)	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0																		
XYLOSE (SS)	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0																		
ACETIC ACID	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0																		
CELLULOSE (IS)	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0																		
OTHERS	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0																		

DWG. No.	REFERENCE DRAWINGS	No.	DATE	REVISION	BY	CK'D	APPR.
		0	01/10/00	FINAL	RML	PT	
		A	06/25/99	DM	RML	DM	

ENGINEERING RECORD
DATE: 06/25/99
SCALE: NONE
DRAWN BY: LANIER
CHECKED BY: DM
APPROVAL:
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VOGELBUSCH USA, INC.
10810 OLD KATY ROAD, SUITE 107
HOUSTON, TEXAS

NATIONAL RENEWABLE ENERGY LABORATORY
Biotechnology Center For Fuels And Chemicals

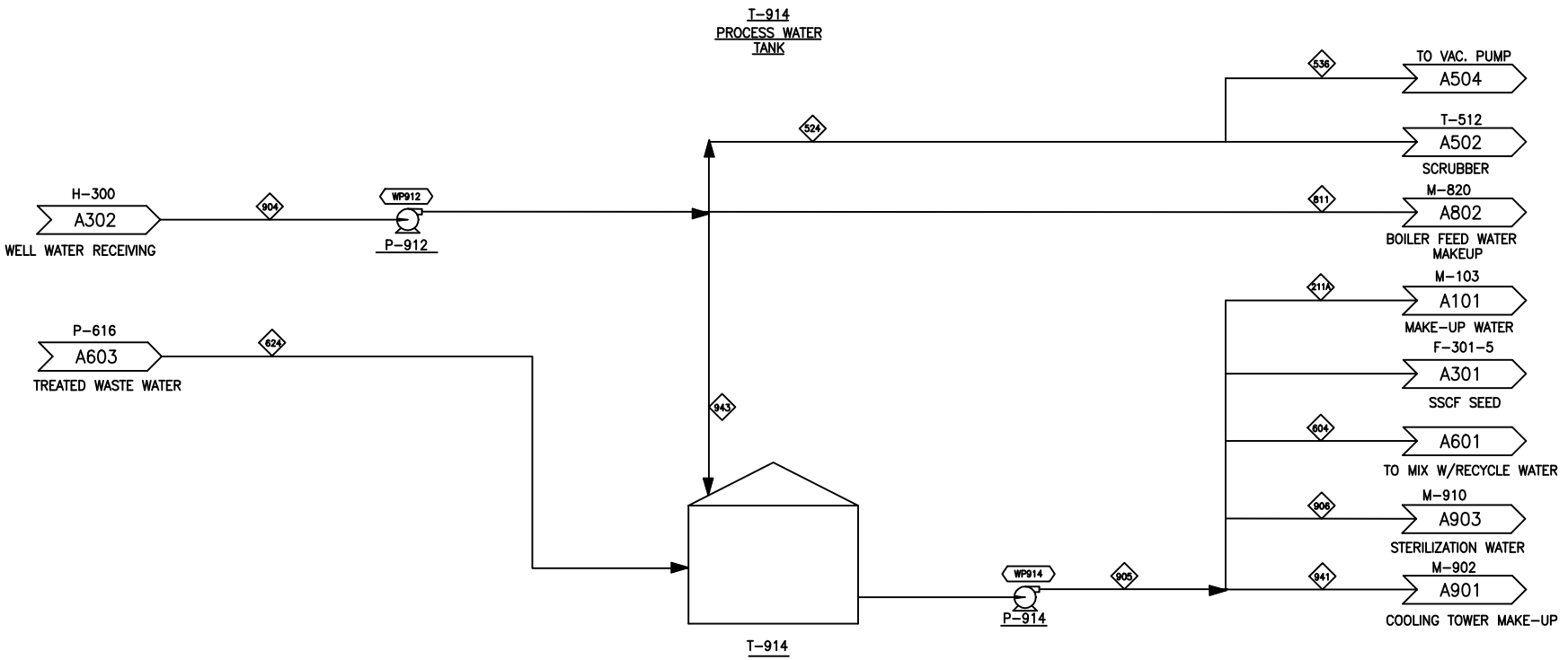
NREL

PROCESS FLOW DIAGRAM
SECTION A900
COOLING WTR PLNT & INST AIR SYS

PROJECT NUMBER	DRAWING NUMBER				
9827	D-900-N-A901	0			
Client	Size	Area	Type	Sequence	Rev.

D900NA901.DWG

01/10/00



STREAM NUMBER	UNITS	211A	524	536	804	624	811	904	905	906	941	943	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
STREAM NAME																																		
TOTAL FLOW	kg/hr	15,196.0	5,410.0	906.0	24,740.0	69,261.6	28,532.4	74,237.2	118,370.8	25.2	78,409.6	40,488.0																						
INSOLUBLE SOLIDS	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%																						
SOLUBLE SOLIDS	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%																						
TEMPERATURE	°C	24	13	13	20	21	26	26	24	20	28	28																						
PRESSURE	atm	1.00	1.00	1.00	1.00	1.00	3.40	1.00	1.00	1.00	1.00	1.00																						
ETHANOL	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0																						
WATER	kg/hr	15,196.0	5,410.0	906.0	24,740.0	69,102.0	28,532.4	74,237.2	118,370.0	25.2	78,409.6	40,488.0																						
GLUCOSE (SS)	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0																						
XYLOSE (SS)	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0																						
ACETIC ACID	kg/hr	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.8	0.0	0.0	0.0																						
CELLULOSE (IS)	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0																						
OTHERS	kg/hr	0.0	0.0	0.0	0.0	159.8	0.0	0.0	158.8	0.0	0.0	0.0																						

DWG. No.	REFERENCE DRAWINGS

No.	DATE	REVISION	BY	CK'D	APPR.
0	01/10/00	FINAL	RML	PT	
A	09/04/99	PRELIMINARY	RML	DM	

ENGINEERING RECORD
DATE: 06/25/99
SCALE: NONE
DRAWN BY: LANIER
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APPROVAL:
APPROVAL:

VOGELBUSCH USA, INC.
10810 OLD KATY ROAD, SUITE 107
HOUSTON, TEXAS

NATIONAL RENEWABLE ENERGY LABORATORY
Biotechnology Center For Fuels And Chemicals

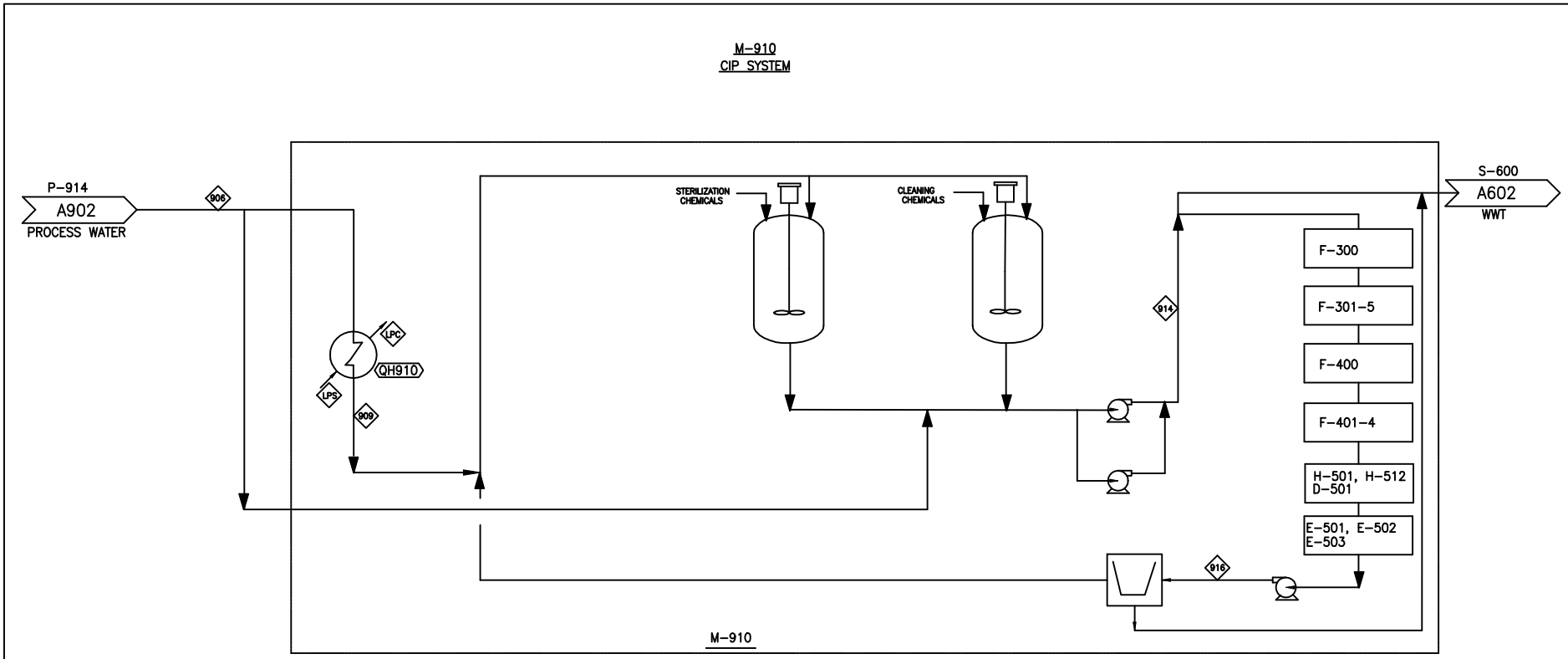
NREL

PROCESS FLOW DIAGRAM
SECTION A900
PROCESS WATER

PROJECT NUMBER	DRAWING NUMBER				
9827	D-900-N-A902				0
Client	Size	Area	Type	Sequence	Rev.

D900NA902.DWG

01/10/00



STREAM NUMBER	UNITS	906	909	914	916	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇
STREAM NAME																																				
TOTAL FLOW	kg/hr	25.2	25.2	25.2	25.2																															
INSOLUBLE SOLIDS	%	0.0%	0.0%	0.0%	0.0%																															
SOLUBLE SOLIDS	%	0.0%	0.0%	0.0%	0.0%																															
TEMPERATURE	°C	20	121	20	20																															
PRESSURE	atm	1.00	1.00	1.00	1.00																															
ETHANOL	kg/hr	0.0	0.0	0.0	0.0																															
WATER	kg/hr	25.2	25.2	25.2	25.2																															
GLUCOSE (SS)	kg/hr	0.0	0.0	0.0	0.0																															
XYLOSE (SS)	kg/hr	0.0	0.0	0.0	0.0																															
ACETIC ACID	kg/hr	0.0	0.0	0.0	0.0																															
CELLULOSE (IS)	kg/hr	0.0	0.0	0.0	0.0																															
OTHERS	kg/hr	0.0	0.0	0.0	0.0																															

DWG. No.	REFERENCE DRAWINGS

No.	DATE	REVISION	BY	CK'D	APPR.
0	01/10/00	FINAL	RML	PT	
A	06/25/99	PRELIMINARY	RML	DM	

ENGINEERING RECORD
DATE: 06/25/99
SCALE: NONE
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APPROVAL:
APPROVAL:

VOGELBUSCH USA, INC.
10810 OLD KATY ROAD, SUITE 107
HOUSTON, TEXAS

NATIONAL RENEWABLE ENERGY LABORATORY
Biotechnology Center For Fuels And Chemicals

NREL

PROCESS FLOW DIAGRAM
SECTION A900
STERILE WATER & CIP/CS SYSTEMS

PROJECT NUMBER	DRAWING NUMBER				
9827	D-900-N-A903				0
Client	Size	Area	Type	Sequence	Rev.

D900NA903.DWG

01/10/00

CAPITAL COST ESTIMATE
Biomass to Ethanol Facility at Chief Ethanol Fuels - Hastings, Nebraska

AREA NO.	AREA DESCRIPTION	EQUIP COST	ERECTION,PIPING,INSULATION		ELECTRICAL & CONTROLS		CONCRETE & STRUCTURAL		TOTAL COST
			FACTOR	COST	FACTOR	COST	FACTOR	COST	
000	SITE & BUILDINGS	$450,000	0.00	$0	0.00	$0	0.00	$0	**$450,000**
100	FEED HANDLING	$5,104,172	0.32	$1,633,335	0.30	$1,531,251	0.40	$2,041,669	**$10,310,427**
200	PREPARATION	$9,808,335	0.57	$5,590,751	0.30	$2,942,501	0.50	$4,904,168	**$23,245,754**
300	FERMENTATION	$6,672,629	0.61	$4,070,304	0.30	$2,001,789	0.20	$1,334,526	**$14,079,248**
500	DISTIL/EVAP/MOLSIEVE	$5,433,500	0.68	$3,694,780	0.40	$2,173,400	0.40	$2,173,400	**$13,475,080**
600	W WATER TREATMENT	$3,351,109	0.30	$1,005,333	0.20	$670,222	1.00	$3,351,109	**$8,377,772**
700	ALCOHOL STORAGE & LO	$710,036	0.30	$213,011	0.25	$177,509	0.40	$284,014	**$1,384,569**
800	BOILER & BFW	$16,659,888	0.40	$6,663,955	0.40	$6,663,955	0.40	$6,663,955	**$36,651,753**
900	COOLING TOWER	$1,815,149	0.40	$726,060	0.30	$544,545	0.30	$544,545	**$3,630,298**
3000	DCS (COMPUTER)	$596,602	0.10	$59,660	0.50	$298,301	0.40	$238,641	**$1,193,203**
TOTAL FOR ALL AREAS		**$50,601,419**		**$23,657,188**		**$17,003,472**		**$21,536,026**	**$112,798,105**

INSTALLED COST

INSTALLED ESTIMATE ABOVE		$112,798,105
CONTINGENCY	10.00%	$11,279,810
TOTAL INSTALLED COST		$124,077,915

PROCESS ENGINEERING (VOGELBUSCH)

ENGINEERING, KNOW-HOW & STARTUP FEE (TYPICAL)	$985,000

DETAILED ENGINEERING & CONSTRUCTION

PERCENTAGE OF INSTALLED COST -	12.00%	$13,535,773

TOTAL CAPITAL COST ESTIMATE $138,598,688

EQUIPMENT LIST SUMMARY

VOGELBUSCH U.S.A., INC.
10810 OLD KATY ROAD, SUITE 107
HOUSTON, TEXAS 77043-5013
(713) 461-7374 / (713) 461-7377 FAX

CLIENT: NREL
Hastings, NE
PROJ: 9827

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			TRAYS & PACKING		COLUMNS & SCRUBBERS		EXCHANGERS		PUMPS		AGITATORS		TANKS & VESSELS		OTHER EQUIPMENT		TOTAL BY AREA	
AREA #	AREA NAME	Y/N	#	COST	#	COST	#	COST	#	COST	#	COST	#	COST	#	COST	ITEMS	COST
100	FEED HANDLING	Y											0	$0	26	$5,104,172	26	$5,104,172
200	PREPARATION	Y					4	$198,210	17	$389,035	3	$47,113	6	$219,912	22	$8,954,066	52	$9,808,335
300	FERMENTATION	Y					24	$366,411	24	$250,252	25	$631,262	30	$5,424,704	0	$0	103	$6,672,629
500	DISTILL/EVAP/MOLSIEVE	Y	5	$180,039	4	$441,947	14	$2,838,969	19	$229,075	1	$35,996	5	$383,977	2	$1,323,498	50	$5,433,500
600	WASTEWATER TREATMENT	Y					1	$66,156	14	$96,335	6	$127,450	8	$1,126,747	28	$1,934,421	57	$3,351,109
700	STORAGE	Y							17	$85,431	0	$0	9	$623,381	1	$1,223	27	$710,036
800	BOILER	Y					1	$14,333	14	$85,437	0	$0	5	$129,008	8	$16,431,110	28	$16,659,888
900	UTILITIES	Y							7	$293,966			2	$116,179	10	$1,405,004	19	$1,815,149
TOTAL	**TOTAL BY EQUIPMENT TYPE**		5	$180,039	4	$441,947	44	$3,484,079	112	$1,429,532	35	$841,822	65	$8,023,907	97	$35,153,493	**362**	**$49,554,817**
																	TOTAL ALL EQUIPMENT	

NOTE: The equipment for the molecular sieve package supplied by Vogelbusch U.S.A., Inc. is included in the Other Equipment column of Area 500 rather than being itemized.

VB PLANT ESTIMATE		DELTA T SCALED ESTIMATE	
EQUIPMENT	INSTALLED	EQUIP (97)	INSTALLED
$49,554,817	**$71,242,393**	**$49,797,587**	**$71,481,894**

EQUIPMENT LIST

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10810 OLD KATY ROAD, SUITE 107
HOUSTON, TEXAS 77043-5013
(713) 461-7374 / (713) 461-7377 FAX

CLIENT: **NREL**
Hastings, NE
PROJ: **9827**
AREA: 100 - STOVER HANDLING
PFD: D-100-N-A101

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EQUIPMENT GROUP: MISCELLANEOUS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO:	CAPACITY	UNITS	FT		DESIGN PSIG	DESIGN °F	MATL	MOTOR HP	MOTOR RPM	VB COST ESTIMATE $ / ITEM	VB COST ESTIMATE TOTAL $	VB COST ESTIMATE INST FACT	VB COST ESTIMATE INSTALLED	DELTA T ESTIMATE SCALED 97	DELTA T ESTIMATE INSTALLED	REMARKS
C-101	BALE CONVEYOR PACKAGE	1	87,460	#/HR					304L SS			$373,945	$373,945	1.30	$486,128	$373,945	$486,128	INCLUDES AUTOMATED STAGING AREA
C-102	SHREDDER CONVEYOR	4	29,153	#/HR					304L SS			$18,737	$74,947	1.30	$97,432	$74,947	$97,432	WITH ROCK TRAP AND MAGNET
C-103	PNEUMATIC CONV SYSTEM	1	87,460	#/HR					304L SS			$40,066	$40,066	1.30	$52,085	$40,066	$52,085	INCLUDES HOPPER TO FEED WEIGH BELT
HM-101	MAMMERMILL PACKAGE	4	29,153	#/HR					304L SS			$638,757	$2,555,027	1.30	$3,321,535	$2,555,027	$3,321,535	COMPLETE WITH DUST COLLECTION
M-101	TRUCK SCALE	3										$25,000	$75,000	1.30	$97,500	$75,000	$97,500	
M-102	FORK TRUCKS	4										$47,000	$188,000	1.00	$188,000	$188,000	$188,000	
SH-101	PRIMARY SHREDDER	4	29,153	#/HR					304L SS			$282,756	$1,131,025	1.30	$1,470,333	$1,131,025	$1,470,333	
SH-102	SECONDARY SHREDDER	4	29,153	#/HR					304L SS			$160,967	$643,867	1.30	$837,027	$643,867	$837,027	
W-104	WEIGH BELT	1	87,460	#/HR								$22,295	$22,295	1.30	$28,984	$22,295	$28,984	
SUBTOTAL	OTHER EQUIPMENT	26								0			$5,104,172	1.29	$6,579,023	$5,104,172	$6,579,023	

AREA 100			DELTA T EST (97)	
EQUIP	INST FACT	INST COST	SCALED 97	INST COST
$5,104,172	1.29	$6,579,023	$5,104,172	$6,579,023

EQUIPMENT LIST

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10810 OLD KATY ROAD, SUITE 107
HOUSTON, TEXAS 77043-5013
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CLIENT: **NREL**
Hastings, NE
PROJ: **9827**
AREA: 200 - PREPARATION
PFD: D-200-N-A201/A202/A203

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EQUIPMENT GROUP: EXCHANGERS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO.	CAPACITY MM BTU/HR	SIZE TYPE	SIZE SQFT	SIZE U VAL	DESIGN PRESS SHELL	DESIGN PRESS TUBE	D.TEMP °F	MATERIALS SHELL	MATERIALS TUBE	VB COST ESTIMATE $ / ITEM	VB COST ESTIMATE TOTAL $	VB COST ESTIMATE INST FACT	VB COST ESTIMATE INSTALLED	DELTA T ESTIMATE SCALED 97	DELTA T ESTIMATE INSTALLED	REMARKS
H-200	HYDROLYZATE LIQ COOLER	1	8.0	NEN	795	200	100/FV	150/FV	365	304L SS	304L SS	$29,099	$29,099	2.10	$61,107	$32,311	$67,853	
H-201A,B,C	BC FEED ECONOMIZER	3	11.0	NEN	2506	100	100/FV	150/FV	365	304L SS	304L SS	$56,370	$169,111	2.10	$355,133	$216,263	$454,153	
SUBTOTAL	EXCHANGERS	4											$198,210	2.10	$416,240	$248,574	$522,005	

EQUIPMENT GROUP: PUMPS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO.	CAPACITY GALS/MIN	SIZE (IN) SUCT	SIZE (IN) DISCH	SIZE (IN) IMP	PRESS FEET	D.TEMP °F	MATL	MOTOR HP	MOTOR RPM	VB COST ESTIMATE $ / ITEM	VB COST ESTIMATE TOTAL $	VB COST ESTIMATE INST FACT	VB COST ESTIMATE INSTALLED	DELTA T ESTIMATE SCALED 97	DELTA T ESTIMATE INSTALLED	REMARKS
P-201	SULFURIC ACID PUMP	2	2					250	316 SS		1750	$3,903	$7,806	2.80	$21,858	$5,139	$14,388	
P-209	OVERLIMED HYDROLYZ. PUMP	2	275					250	316 SS		1750	$7,603	$15,206	2.80	$42,578	$12,791	$35,815	
P-222	FILTERED HYDRLYZATE PUMP	2	288					250	316 SS		1750	$7,694	$15,389	2.80	$43,088	$13,119	$36,734	
P-224	FERMENTATION FEED PUMP	3	294					250	316 SS		1750	$97,682	$293,046	2.80	$820,528	$293,046	$820,528	ROTARY-LOBE, SCALED, 0.7 FACTOR
P-225	ISEP ELUTION PUMP	2	93					250	316 SS		1750	$6,740	$13,481	2.80	$37,746	$9,128	$25,559	
P-226	ISEP RELOAD PUMP	2	143					250	316 SS		1750	$6,721	$13,443	2.80	$37,640	$10,401	$29,121	
P-227	ISEP HYDROLYZ FEED PUMP	2	280					250	316 SS		1750	$7,635	$15,271	2.80	$42,758	$12,828	$35,918	
P-239	REACIDIFICATION PUMP	2	289					250	316 SS		1750	$7,697	$15,394	2.80	$43,103	$12,911	$36,150	
SUBTOTAL	PUMPS	17								0			$389,035	2.80	$1,089,298	$369,362	$1,034,213	

EQUIPMENT GROUP: AGITATORS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO:	TANK CAP GALLONS	SIZE (FT) DIA	SIZE (FT) S.SIDE	SHAFT DIA IN	MOUNT TYPE	D.TEMP °F	MATL	AGITATOR HP	AGITATOR RPM	VB COST ESTIMATE $ / ITEM	VB COST ESTIMATE TOTAL $	VB COST ESTIMATE INST FACT	VB COST ESTIMATE INSTALLED	DELTA T ESTIMATE SCALED 97	DELTA T ESTIMATE INSTALLED	REMARKS
A-209	OVERLIMING TANK AGIT.	1	18,485	15	14		TOP	250	304 SS			$12,793	$12,793	1.30	$16,630	$14,203	$18,463	ASSUMED HIGH VISC - 2.15 COST FACTOR
A-224	REACIDIFICATION TANK AGIT.	1	74,041	23	23		TOP	250	304 SS			$23,123	$23,123	1.20	$27,748	$46,769	$56,123	ASSUMED HIGH VISC - 2.15 COST FACTOR
A-232	RESLURRYING TANK AGIT.	1	9,907	12	12		TOP	250	304 SS			$11,198	$11,198	1.20	$13,437	$22,686	$27,223	ASSUMED HIGH VISC - 2.15 COST FACTOR
SUBTOTAL	AGITATORS	3								0			$47,113	1.23	$57,815	$83,658	$101,809	

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EQUIPMENT GROUP: TANKS/VESSELS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO:	CAPACITY GALLONS	SIZE (FT) DIA	SIZE (FT) S.SIDE		PRESS PSIG	D.TEMP °F	MATL	DESIGN CODE DESIGN	DESIGN CODE NO.	VB COST ESTIMATE $ / ITEM	VB COST ESTIMATE TOTAL $	VB COST ESTIMATE INST FACT	VB COST ESTIMATE INSTALLED	DELTA T ESTIMATE SCALED 97	DELTA T ESTIMATE INSTALLED	REMARKS
T-201	SULFURIC DAY TANK	1	2,578	8	7		ATM	212	PLASTIC		650	$3,284	$3,284	1.40	$4,598	$3,284	$4,598	SCALED ON VOLUME, 0.71 FACTOR
T-203	BLOWDOWN TANK	1	5,789	10	10		ATM	212	304 SS	API	620	$18,735	$18,735	1.20	$22,482	$27,316	$32,780	
T-209	OVERLIMING TANK	1	18,487	15	14		ATM	212	304 SS	API	620	$36,027	$36,027	1.40	$50,438	$44,707	$62,590	
T-220	LIME STORAGE BIN	1	13,331	10	22		ATM	212	CS	API	650	$51,275	$51,275	1.30	$66,657	$51,275	$66,657	SCALED ON VOLUME, 0.46 FACTOR
T-224	REACIDIFICATION TANK	1	74,051	23	23		ATM	212	304 SS	API	650	$86,245	$86,245	1.20	$103,494	$106,019	$127,223	
T-232	RESLURRYING TANK	1	9,908	12	12		ATM	212	304 SS	API	650	$24,345	$24,345	1.20	$29,214	$23,556	$28,267	
SUBTOTAL	TANKS/VESSELS	6											$219,912	1.26	$276,884	$256,158	$322,115	

EQUIPMENT GROUP: MISCELLANEOUS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO:	CAPACITY	UNITS	FT		DESIGN PSIG	DESIGN °F	MATL	MOTOR HP	MOTOR RPM	VB COST ESTIMATE $ / ITEM	VB COST ESTIMATE TOTAL $	VB COST ESTIMATE INST FACT	VB COST ESTIMATE INSTALLED	DELTA T ESTIMATE SCALED 97	DELTA T ESTIMATE INSTALLED	REMARKS
A-201	IN-LINE SULF. ACID MIXER	1	99	GPM	1149.8				304L SS			$1,150	$1,150	1.00	$1,150	$1,150	$1,150	SCALED ON FLOW, 0.48 FACTOR
A-202	IN-LINE AMMONIA MIXER	1	96	GPM	1075.1				304L SS			$1,075	$1,075	1.00	$1,075	$1,075	$1,075	SCALED ON FLOW, 0.48 FACTOR
A-235	IN-LINE ACIDIFICATION MIXER	1	288	#/HR					304L SS			$1,902	$1,902	1.00	$1,902	$1,902	$1,902	SCALED ON FLOW, 0.48 FACTOR
C-201	HYDROLYZATE SCREW CONV	1	90,056	#/HR					304L SS			$29,045	$29,045	1.30	$37,759	$29,045	$37,759	SCALED ON FLOW, 0.78 FACTOR
C-202	WASH SOLIDS SCREW CONV	4	78,688	#/HR					304L SS			$7,092	$28,368	1.30	$36,878	$28,368	$36,878	SCALED ON FLOW, 1.0 FACTOR
C-225	LIME SOLIDS FEEDER	1	482	#/HR					304L SS			$3,900	$3,900	1.30	$5,070	$3,900	$5,070	NOT SCALED
M-202	HYDROLYZER	1	237,628	#/HR								$6,098,532	$6,098,532	1.50	$9,147,797	$6,098,532	$9,147,797	HASTELLOY C20, SCALED, 0.78 FACTOR
P-223	LIME TRANSFER BLOWER	1	480	SCFM					CS			$34,394	$34,394	1.40	$48,152	$34,394	$48,152	SCALED ON FLOW, 0.5 FACTOR
S-202	PRE-IX FILTER PRESS	8	52,260	#/HR					304L SS			$141,613	$1,132,906	1.40	$1,586,069	$1,132,906	$1,586,069	SCALED ON FLOW, 0.39 FACTOR
S-221	ISEP	1	0	#/HR					304L SS			$1,520,154	$1,520,154	1.20	$1,824,185	$1,520,154	$1,824,185	SCALED ON FLOW, 0.33 FACTOR
S-222	HYDROCLONE/DRUM FILTER	1	147,206	#/HR					SS/PP/LINED			$85,858	$85,858	1.40	$120,202	$85,858	$120,202	SCALED ON FLOW, 0.39 FACTOR
S-227	LIME DUST BAGHOUSE	1	3,333	SCFM					EPOXY LINED			$16,781	$16,781	1.50	$25,171	$16,781	$25,171	SCALED ON FLOW, 1.0 FACTOR
SUBTOTAL	OTHER EQUIPMENT	22								0			$8,954,066	1.43	$12,835,410	$8,954,066	$12,835,410	

AREA 200			DELTA T EST (97)	
EQUIP	INST FACT	INST COST	SCALED 97	INST COST
$9,808,335	1.50	$14,675,647	$9,911,817	$14,815,553

EQUIPMENT LIST

VOGELBUSCH U.S.A., INC.
10810 OLD KATY ROAD, SUITE 107
HOUSTON, TEXAS 77043-5013
(713) 461-7374 / (713) 461-7377 FAX

CLIENT: **NREL**
Hastings, NE
PROJ: **9827**
AREA: 300 - FERMENTATION
PFD: D-300-N-A301/A302

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EQUIPMENT GROUP: EXCHANGERS

EQUIP	EQUIPMENT DESCRIPTION	NO.	CAPACITY	SIZE			DESIGN PRESS		D.TEMP	MATERIALS		VB COST ESTIMATE				DELTA T ESTIMATE		REMARKS
NUMBER	NAME		MM BTU/HR	TYPE	SQFT	U VAL	SHELL	TUBE	°F	SHELL	TUBE	$ / ITEM	TOTAL $	INST FACT	INSTALLED	SCALED 97	INSTALLED	
H-300	SSCF COOLER	18	0.4	WPLAT	53	250	150	125	200	304L SS	304L SS	$13,868	$249,620	2.10	$524,201	$43,923	$92,239	
H-301	SEED HYDROLYZ. COOLER	1	1.6	WPLAT	309	250	150	125	200	304L SS	304L SS	$22,314	$22,314	2.10	$46,859	$7,053	$14,812	
H-302	HYDROLYZATE COOLER	3	3.7	WPLAT	502	300	150	125	200	304L SS	304L SS	$28,675	$86,024	2.10	$180,650	$36,799	$77,277	
H-304	4TH SEED FERMENTER COILS	1	0.002	COILS	11	300	150	125	200	304L SS	304L SS	$1,433	$1,433	1.20	$1,720	$1,433	$1,720	SCALED ON AREA, 0.83 FACTOR
H-305	5TH SEED FERMENTER COILS	1	0.2	COILS	123	300	150	125	200	304L SS	304L SS	$7,021	$7,021	1.20	$8,425	$7,021	$8,425	SCALED ON AREA, 0.98 FACTOR
SUBTOTAL	EXCHANGERS	24											$366,411	2.08	$761,855	$96,229	$194,473	

EQUIPMENT GROUP: PUMPS

EQUIP	EQUIPMENT DESCRIPTION	NO.	CAPACITY	SIZE (IN)			PRESS	D.TEMP	MATL	MOTOR		VB COST ESTIMATE				DELTA T ESTIMATE		REMARKS
NUMBER	NAME		GALS/MIN	SUCT	DISCH	IMP	FEET	°F		HP	RPM	$ / ITEM	TOTAL $	INST FACT	INSTALLED	SCALED 97	INSTALLED	
P-300	RECIRC/TRANSFER PUMP	18	424				169	212	316 SS		1750	$8,600	$154,802	2.80	$433,446	$87,376	$244,654	
P-301	SSCF SEED TRANSF. PUMP	2	69				164	212	316 SS		1750	$10,936	$21,871	1.40	$30,620	$21,871	$30,620	ROTARY-LOBE, SCALED, 0.7 FACTOR
P-302	SEED TRANSFER PUMP	2	246				145	212	316 SS		1750	$26,651	$53,302	1.40	$74,623	$53,302	$74,623	ROTARY-LOBE, SCALED, 0.7 FACTOR
P-306	BEER TRANSFER PUMP	2	653				145	212	316 SS		1750	$10,138	$20,277	2.80	$56,775	$16,725	$46,829	
SUBTOTAL	PUMPS	24								0			$250,252	2.38	$595,464	$179,274	$396,726	

EQUIPMENT GROUP: AGITATORS

EQUIP	EQUIPMENT DESCRIPTION	NO:	TANK CAP	SIZE (FT)		SHAFT	MOUNT	D.TEMP	MATL	AGITATOR		VB COST ESTIMATE				DELTA T ESTIMATE		REMARKS
NUMBER	NAME		GALLONS	DIA	S.SIDE	DIA IN	TYPE	°F		HP	RPM	$ / ITEM	TOTAL $	INST FACT	INSTALLED	SCALED 97	INSTALLED	
A-300	SSCF FERMENTER AGITATOR	18	385,009	42	38		TOP	212	304 SS			$30,400	$547,208	1.20	$656,650	$408,767	$490,520	1 TOP MOUNT/TANK RATHER THAN 2 SIDE
A-301	SEED HOLD TANK AGITATOR	2	93,321	25	25		TOP	212	304 SS			$12,422	$24,845	1.20	$29,814	$14,988	$17,985	
A-304	4TH SEED FERM AGITATOR	2	7,777	11	12		TOP	212	304 SS			$5,024	$10,048	1.20	$12,057	$13,972	$16,766	
A-305	5TH SEED FERM AGITATOR	2	77,767	24	23		TOP	212	304 SS			$11,077	$22,154	1.20	$26,585	$12,348	$14,818	
A-306	BEERWELL AGITATOR	1	329,956	39	38		TOP	212	304 SS			$27,007	$27,007	1.20	$32,409	$12,903	$15,483	
SUBTOTAL	AGITATORS	25								0			$631,262	1.20	$757,515	$462,977	$555,573	

EQUIPMENT LIST

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CLIENT: **NREL**
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PROJ: **9827**
AREA: 300 - FERMENTATION
PFD: D-300-N-A301/A302

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REVISIONS

NO.	DATE	BY
A	9/3/99	DM

EQUIPMENT GROUP: TANKS/VESSELS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO:	CAPACITY GALLONS	SIZE (FT) DIA	SIZE (FT) S.SIDE		PRESS PSIG	D.TEMP °F	MATL	DESIGN CODE DESIGN	DESIGN CODE NO.	VB COST ESTIMATE $ / ITEM	VB COST ESTIMATE TOTAL $	VB COST ESTIMATE INST FACT	VB COST ESTIMATE INSTALLED	DELTA T ESTIMATE SCALED 97	DELTA T ESTIMATE INSTALLED	REMARKS
F-300	SSCF VESSELS	18	385,009	42	38		2.5	212	304 SS	API	620	$266,262	$4,792,717	1.20	$5,751,261	$5,565,250	$6,678,301	
F-301	1ST SSCF SEED VESSEL	2	19	2	1		100/FV	400	304 SS	ASME	VIII-1	$8,987	$17,974	2.80	$50,327	$29,400	$82,320	NOT SCALED
F-302	2ND SSCF SEED VESSEL	2	194	3	3		100/FV	400	304 SS	ASME	VIII-1	$10,095	$20,190	2.80	$56,533	$65,200	$182,560	NOT SCALED
F-303	3RD SSCF SEED VESSEL	2	1,944	8	6		100/FV	400	304 SS	ASME	VIII-1	$21,177	$42,354	2.80	$118,591	$162,200	$454,160	NOT SCALED
F-304	4TH SSCF SEED VESSEL	2	7,777	11	12		2.5	212	304 SS	API	620	$21,442	$42,883	1.20	$51,460	$30,849	$37,019	
F-305	5TH SSCF SEED VESSEL	2	77,767	24	23		2.5	212	304 SS	API	620	$88,396	$176,793	1.20	$212,151	$175,840	$211,008	
T-301	SSCF SEED HOLD TANK	1	93,321	25	25		2.5	212	304 SS	API	620	$97,401	$97,401	1.20	$116,881	$96,487	$115,785	
T-306	BEER WELL	1	329,956	39	38		2.5	212	304 SS	API	620	$234,391	$234,391	1.20	$281,270	$285,782	$342,938	
SUBTOTAL	TANKS/VESSELS	30											$5,424,704	1.22	$6,638,474	$6,411,009	$8,104,090	

AREA 300			DELTA T EST (97)	
EQUIP	INST FACT	INST COST	SCALED 97	INST COST
$6,672,629	**1.31**	**$8,753,307**	**$7,149,490**	**$9,250,862**

EQUIPMENT LIST

VOGELBUSCH U.S.A., INC.
10810 OLD KATY ROAD, SUITE 107
HOUSTON, TEXAS 77043-5013
(713) 461-7374 / (713) 461-7377 FAX

CLIENT: **NREL**
Hastings, NE
PROJ: **9827**
AREA: 500 - DISTILL/EVAP/MOLSIEVE
PFD: D-500-N-A501/A502/A503/A504

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NO.	DATE	BY
A	9/3/99	DM

EQUIPMENT GROUP: TRAYS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO.	TRAYED SECTION						DESIGN		MATL	VB COST ESTIMATE				DELTA T ESTIMATE		REMARKS
			FT^2/TRAY	NO	ID FT	TYPE	SPACE	WT LB	PSIG	°F		$ / ITEM	TOTAL $	INST FACT	INSTALLED	SCALED 97	INSTALLED	
DT-501A	BEER COLUMN TRAYS	1	50.27	22	8.0	FVALVE	24"			320	316 SS	$57,592	$57,592	1.00	$57,592	$0	$0	INCLUDES INSTALLATION
DT-501B	BC DEGASSER TRAYS	1	23.76	8	5.5	FVALVE	30"			320	316 SS	$15,735	$15,735	1.00	$15,735	$0	$0	INCLUDES INSTALLATION
DT-502	RECTIFYING COLUMN TRAYS	1	56.75	33	8.5	VALVE	20"			320	316 SS	$69,913	$69,913	1.00	$69,913	$0	$0	INCLUDES INSTALLATION
DT-503	STRIPPING COLUMN TRAYS	1	7.07	16	3.0	VALVE	20"			320	316 SS	$16,091	$16,091	1.00	$16,091	$0	$0	INCLUDES INSTALLATION
SUBTOTAL	TRAYS	4											$159,331	1.00	$159,331	$0	$0	

EQUIPMENT GROUP: PACKING

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO.	PACKING	PACKED SECTION					DESIGN		MATL	VB COST ESTIMATE				DELTA T ESTIMATE		REMARKS
			CU FT	ID FT	SS FT	TYPE	SIZE	WT LB	PSIG	°F		$ / ITEM	TOTAL $	INST FACT	INSTALLED	SCALED 97	INSTALLED	
TP-512	CO2 SCRUBBER PACKING	1	188	4.0	15	PALL	1"			250	316L SS	$20,708	$20,708	1.00	$20,708	$0	$0	INCLUDES 316L SS HARDWARE
SUBTOTAL	PACKING	1	188										$20,708	1.00	$20,708	$0	$0	

EQUIPMENT GROUP: COLUMNS & SCRUBBERS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO.	CAPACITY	SIZE		DESIGN		MATL	TRAYS			VB COST ESTIMATE				DELTA T ESTIMATE		REMARKS
			GALLONS	ID FT	SS FT	PSIG	°F		TYPE	SPACE	NO.	$ / ITEM	TOTAL $	INST FACT	INSTALLED	SCALED 97	INSTALLED	
D-501	BEER COLUMN	1	35,719	8.0	95	55/FV	320	304L SS	FVALVE	24"/30"		$200,515	$200,515	2.10	$421,082	$267,313	$561,357	
D-502	RECTIFYING COLUMN	1	33,956	8.5	80	55/FV	320	304L SS	VALVE	20"		$168,495	$168,495	2.10	$353,840	$256,349	$538,333	
D-503	STRIPPING COLUMN	1	2,115	3.0	40	55/FV	320	304L SS	VALVE	20"		$47,878	$47,878	2.10	$100,544	$50,495	$106,039	
T-512	CO2 SCRUBBER	1	2,350	4.0	25	55/FV	320	304L SS	PACK	0		$25,058	$25,058	2.10	$52,623	$41,202	$86,523	
SUBTOTAL	COLUMNS & SCRUBBERS	4											$441,947	2.10	$928,088	$615,358	$1,292,252	
																VB W/ INTERNALS		
																$621,985	$1,108,127	

EQUIPMENT GROUP: EXCHANGERS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO.	CAPACITY	SIZE			DESIGN PRESS		D.TEMP	MATERIALS		VB COST ESTIMATE				DELTA T ESTIMATE		REMARKS
			MM BTU/HR	TYPE	SQFT	U VAL	SHELL	TUBE	°F	SHELL	TUBE	$ / ITEM	TOTAL $	INST FACT	INSTALLED	SCALED 97	INSTALLED	
E-501	1ST EFFECT EVAPORATOR	1	44.9	NEN	30750	139	55/FV	60/FV	300	304L SS	304L SS	$782,358	$782,358	2.10	$1,642,952	$782,358	$1,642,952	SCALED ON AREA, 0.68 FACTOR
E-502	2ND EFFECT EVAPORATOR	1	62.5	NEN	30750	163	55/FV	60/FV	300	304L SS	304L SS	$625,888	$625,888	2.10	$1,314,364	$625,888	$1,314,364	SCALED ON AREA, 0.68 FACTOR
E-503	3RD EFFECT EVAPORATOR	1	56.1	NEN	30750	172	55/FV	60/FV	300	304L SS	304L SS	$625,888	$625,888	2.10	$1,314,364	$625,888	$1,314,364	SCALED ON AREA, 0.68 FACTOR
H-501 A/B	BC REBOILER	2	30.4	NEN	4324	190	200/FV	200/FV	400	CS	316L SS	$144,693	$289,386	2.10	$607,711	$142,335	$298,904	
H-502	RECYCLE FEED HEATER	1	0.75	PLATE	48	400	150	100	250	CS(FRM)	316L SS	$2,109	$2,109	2.10	$4,429	$2,178	$4,574	
H-503	SC REBOILER	1	7.8	AEM	723	200	200/FV	55/FV	300	CS	304L SS	$20,896	$20,896	2.10	$43,881	$22,219	$46,659	
H-504	BEER COL CONDENSER	1	2.3	NEN	318	100	55/FV	150	300	304L SS	304L SS	$20,240	$20,240	2.10	$42,503	$13,653	$28,670	
H-504A	DEGAS COOLER	1	0.14	NEN	195	70	55/FV	150	300	304L SS	304L SS	$6,488	$6,488	2.10	$13,625	$9,790	$20,559	
H-505	RC OVHD CONDENSER	1	45.1	NEN	4448	130	55/FV	150	300	CS	304L SS	$69,805	$69,805	2.10	$146,590	$28,614	$60,089	
H-512 A/B	BC FEED INTERCHANGER	2	4.3	SPIRAL	1108	130	175	150	300	316L SS	316L SS	$93,512	$187,025	2.10	$392,752	$187,025	$392,752	
H-517 A/B	EVAPORATOR CONDENSER	2	61.6	NEN	11640	220	60/FV	150	300	304L SS	304L SS	$104,443	$208,887	2.10	$438,662	$344,364	$723,164	
SUBTOTAL	EXCHANGERS	14											$2,838,969	2.10	$5,961,835	$2,784,310	$5,847,052	
																USED OUR		
																SPIRAL EST		

EQUIPMENT LIST

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CLIENT: **NREL**
Hastings, NE
PROJ: **9827**
AREA: 500 - DISTILL/EVAP/MOLSIEVE
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EQUIPMENT GROUP: PUMPS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO.	CAPACITY GALS/MIN	SIZE (IN) SUCT	SIZE (IN) DISCH	SIZE (IN) IMP	PRESS FEET	D.TEMP °F	MATL	MOTOR HP	MOTOR RPM	VB COST ESTIMATE $ / ITEM	VB COST ESTIMATE TOTAL $	VB COST ESTIMATE INST FACT	VB COST ESTIMATE INSTALLED	DELTA T ESTIMATE SCALED 97	DELTA T ESTIMATE INSTALLED	REMARKS
P-501 A/B	BEER COL BOTTOMS PUMP	2	5375				164	250	316 SS		1750	$41,775	$83,549	2.80	$233,937	$89,007	$249,218	
P-503 A/B	BC REFLUX PUMP	2	13				147	250	CS		1750	$3,406	$6,813	2.80	$19,075	$2,617	$7,326	
P-504 A/B	RC BOTTOMS PUMP	2	153				116	250	316 SS		1750	$6,787	$13,574	2.80	$38,008	$9,632	$26,970	
P-505 A/B	RC REFLUX PUMP	2	402				113	250	316 SS		1750	$8,455	$16,911	2.80	$47,350	$8,867	$24,826	
P-506 A/B	SC BOTTOMS PUMP	2	125				173	250	316 SS		1750	$6,600	$13,199	2.80	$36,957	$8,211	$22,990	
P-511 A/B	1ST EFFECT EVAP PUMP	2	971				166	250	316 SS		1750	$12,268	$24,535	2.80	$68,699	$18,809	$52,666	
P-512 A/B	2ND EFFECT EVAP PUMP	2	1063				104	250	316 SS		1750	$12,884	$25,768	2.80	$72,151	$21,042	$58,918	
P-513 A/B	3RD EFFECT EVAP PUMP	2	807				104	250	316 SS		1750	$11,169	$22,338	2.80	$62,546	$15,930	$44,604	
P-514 A/B	EVAP. CONDENSATE PUMP	2	421				103	250	316 SS		1750	$8,583	$17,165	2.80	$48,063	$20,660	$57,848	
P-515	SCRUBBER BTMS PUMP	1	44				80	250	316 SS		1750	$5,222	$5,222	2.80	$14,622	$1,772	$4,963	
SUBTOTAL	PUMPS	19								0			$229,075	2.80	$641,409	$196,547	$550,330	

EQUIPMENT GROUP: AGITATORS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO:	TANK CAP GALLONS	SIZE (FT) DIA	SIZE (FT) S.SIDE	SHAFT DIA IN	MOUNT TYPE	D.TEMP °F	MATL	AGITATOR HP	AGITATOR RPM	VB COST ESTIMATE $ / ITEM	VB COST ESTIMATE TOTAL $	VB COST ESTIMATE INST FACT	VB COST ESTIMATE INSTALLED	DELTA T ESTIMATE SCALED 97	DELTA T ESTIMATE INSTALLED	REMARKS
A-520	EVAP FEED TANK AGITATOR	1	475,794	45	40		TOP	212	304 SS			$35,996	$35,996	1.20	$43,195	$22,140	$26,568	
SUBTOTAL	AGITATORS	1								0			$35,996	1.20	$43,195	$22,140	$26,568	

EQUIPMENT GROUP: TANKS/VESSELS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO:	CAPACITY GALLONS	SIZE (FT) DIA	SIZE (FT) S.SIDE		PRESS PSIG	D.TEMP °F	MATL	DESIGN CODE DESIGN	DESIGN CODE NO.	VB COST ESTIMATE $ / ITEM	VB COST ESTIMATE TOTAL $	VB COST ESTIMATE INST FACT	VB COST ESTIMATE INSTALLED	DELTA T ESTIMATE SCALED 97	DELTA T ESTIMATE INSTALLED	REMARKS
T-502	MIST ELIMINATOR	1	576	3.5	8.0		55/FV	320	304L SS	ASME	VIII-1	$13,891	$13,891	2.10	$29,171	$13,891	$29,171	
T-503	BC REFLUX DRUM	1	147	2.5	4.0		55/FV	320	304L SS	ASME	VIII-1	$9,798	$9,798	2.10	$20,575	$4,550	$9,556	
T-505	RC REFLUX DRUM	1	1,762	5.0	12.0		55/FV	320	304L SS	ASME	VIII-1	$20,025	$20,025	2.10	$42,051	$10,644	$22,353	
T-517	CONDENSATE DRUM	1	1,762	5.0	12.0		55/FV	320	CS	ASME	VIII-1	$21,483	$21,483	2.10	$45,113	$10,644	$22,353	
T-520	EVAPORATOR FEED TANK	1	475,730	45.0	40.0		ATM	212	304L SS	API	650	$318,782	$318,782	1.20	$382,538	$206,471	$247,765	
SUBTOTAL	TANKS/VESSELS	5											$383,977	1.35	$519,448	$246,201	$331,197	

USED OUR MIST E EST

EQUIPMENT GROUP: MISCELLANEOUS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO:	CAPACITY	UNITS			DESIGN PSIG	DESIGN °F	MATL	MOTOR HP	MOTOR RPM	VB COST ESTIMATE $ / ITEM	VB COST ESTIMATE TOTAL $	VB COST ESTIMATE INST FACT	VB COST ESTIMATE INSTALLED	DELTA T ESTIMATE SCALED 97	DELTA T ESTIMATE INSTALLED	REMARKS
M-501	EVAP VAC. PUMP PACKAGE	1	64	#/HR (AIR+VAPOR)			55/FV	320	316 SS			$11,464	$11,464	2.80	$32,098	$11,464	$32,098	
	MOLE SIEVE PACKAGE	1										$1,312,035	$1,312,035	1.00	$1,312,035	$1,326,390	$1,326,390	
SUBTOTAL	OTHER EQUIPMENT	2											$1,323,498	1.02	$1,344,133	$1,337,854	$1,358,488	

USED OUR VPUMP EST

AREA 500 EQUIP	AREA 500 INST FACT	AREA 500 INST COST	DELTA T EST (97) SCALED 97	DELTA T EST (97) INST COST
$5,433,500	1.77	**$9,618,146**	**$5,202,410**	**$9,405,888**

EQUIPMENT LIST

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(713) 461-7374 / (713) 461-7377 FAX

CLIENT: **NREL**
Hastings, NE
PROJ: **9827**
AREA: 600 - WASTEWATER TREATMENT
PFD: D-600-N-A601/A602/A603

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EQUIPMENT GROUP: EXCHANGERS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO.	CAPACITY MM BTU/HR	SIZE TYPE	SIZE SQFT	SIZE U VAL	DESIGN PRESS SHELL	DESIGN PRESS TUBE	D.TEMP DEG F	MATERIALS SHELL	MATERIALS TUBE	VB COST ESTIMATE $ / ITEM	VB COST ESTIMATE TOTAL $	VB COST ESTIMATE INST FACT	VB COST ESTIMATE INSTALLED	DELTA T ESTIMATE SCALED 97	DELTA T ESTIMATE INSTALLED	REMARKS
H-602	ANAEROBIC FEED COOLER	1	11.6	NEN	3050.8	250	150	125	200	304L SS	304L SS	$66,156	$66,156	2.10	$138,928	$64,166	$134,748	
SUBTOTAL	EXCHANGERS	1											$66,156	2.10	$138,928	$64,166	$134,748	

EQUIPMENT GROUP: PUMPS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO.	CAPACITY GALS/MIN	SIZE (IN) SUCT	SIZE (IN) DISCH	SIZE (IN) IMP	PRESS FEET	D.TEMP °F	MATL	MOTOR HP	MOTOR RPM	VB COST ESTIMATE $ / ITEM	VB COST ESTIMATE TOTAL $	VB COST ESTIMATE INST FACT	VB COST ESTIMATE INSTALLED	DELTA T ESTIMATE SCALED 97	DELTA T ESTIMATE INSTALLED	REMARKS
P-602	ANAER REACTR FEED PUMP	2	350					212	316 SS		1750	$8,110	$16,219	2.80	$45,414	$10,645	$29,807	
P-606	ANAER. DIGEST. FEED PUMP	2	332					212	316 SS		1750	$7,989	$15,978	2.80	$44,739	$9,984	$27,957	
P-608	AER. SLUDGE RECYC. PUMP	1	10					212	316 SS		1750	$4,165	$4,165	1.40	$5,830	$5,127	$7,178	
P-610	AEROBIC SLUDGE PUMP	1	10					212	316 SS		1750	$4,165	$4,165	1.40	$5,830	$5,127	$7,178	
P-611	AER. DIGESTION OUT. PUMP	2	331					212	316 SS		1750	$7,981	$15,962	2.80	$44,694	$9,974	$27,928	
P-614	SLUDGE FILT RECYCL PUMP	2	9					212	316 SS		1750	$4,127	$8,254	2.80	$23,112	$5,637	$15,783	
P-616	TREATED WATER PUMP	2	321					212	316 SS		1750	$7,914	$15,828	2.80	$44,319	$9,884	$27,676	
P-630	RECYCLE WATER PUMP	2	316					212	316 SS		1750	$7,882	$15,764	2.80	$44,139	$9,898	$27,714	
SUBTOTAL	PUMPS	14								0			$96,335	2.68	$258,077	$66,277	$171,219	

EQUIPMENT GROUP: AGITATORS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO:	TANK CAP GALLONS	SIZE (FT) DIA	SIZE (FT) S.SIDE	SHAFT DIA IN	MOUNT TYPE	D.TEMP °F	MATL	AGITATOR HP	AGITATOR RPM	VB COST ESTIMATE $ / ITEM	VB COST ESTIMATE TOTAL $	VB COST ESTIMATE INST FACT	VB COST ESTIMATE INSTALLED	DELTA T ESTIMATE SCALED 97	DELTA T ESTIMATE INSTALLED	REMARKS
A-602	EQUALIZATION BASIN AGIT.	1	150,986	29.8	28.9		TOP	212	304 SS			$15,977	$15,977	1.20	$19,172	$17,369	$20,843	
A-606	ANAEROBIC DIGESTOR AGIT	4	324,057	34.6	46.0		TOP	212	304 SS			$26,644	$106,575	1.20	$127,890	$76,779	$92,135	
A-630	RECYCLE WATER TANK AGIT	1	6,324	10.3	10.1		TOP	212	304 SS			$4,898	$4,898	1.30	$6,368	$3,647	$4,741	
SUBTOTAL	AGITATORS	6								0			$127,450	1.20	$153,430	$97,795	$117,719	

EQUIPMENT GROUP: TANKS/VESSELS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO:	CAPACITY GALLONS	SIZE (FT) DIA	SIZE (FT) S.SIDE		PRESS PSIG	D.TEMP °F	MATL	DESIGN CODE DESIGN	DESIGN CODE NO.	VB COST ESTIMATE $ / ITEM	VB COST ESTIMATE TOTAL $	VB COST ESTIMATE INST FACT	VB COST ESTIMATE INSTALLED	DELTA T ESTIMATE SCALED 97	DELTA T ESTIMATE INSTALLED	REMARKS
T-602	EQUALIZATION BASIN	1	150,986	30	29		TOP	250				$214,546	$214,546	1.42	$304,656	$214,546	$304,656	CONCRETE, SCALED, 0.51 FACTOR
T-606	ANAEROBIC DIGESTOR	4	324,057	35	46		TOP	250				$139,539	$558,158	1.04	$580,484	$558,158	$580,484	EPOXY LINED, SCALED, 0.51 FACTOR
T-608	AEROBIC DIGESTOR	1	7,798,957	163	50		TOP	250				$242,542	$242,542	1.00	$242,542	$242,542	$242,542	POLYMER LINED, SCALED, 1.0 FACTOR
T-610	CLARIFIER	1	78,105	28	17		TOP	250				$106,602	$106,602	1.96	$208,940	$106,602	$208,940	CONCRETE, SCALED, 0.51 FACTOR
T-630	RECYCLE WATER TANK	1	6,324	10	10		TOP	212	CS			$4,898	$4,898	1.40	$6,858	$7,077	$9,908	
SUBTOTAL	TANKS/VESSELS	8											$1,126,747	1.19	$1,343,480	$1,128,925	$1,346,530	

EQUIPMENT LIST

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CLIENT: **NREL**
Hastings, NE
PROJ: **9827**
AREA: 600 - WASTEWATER TREATMENT
PFD: D-600-N-A601/A602/A603

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EQUIPMENT GROUP : MISCELLANEOUS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO.	CAPACITY	UNITS			DESIGN PSIG	DESIGN °F	MATL	MOTOR HP	MOTOR RPM	VB COST ESTIMATE $ / ITEM	VB COST ESTIMATE TOTAL $	VB COST ESTIMATE INST FACT	VB COST ESTIMATE INSTALLED	DELTA T ESTIMATE SCALED 97	DELTA T ESTIMATE INSTALLED	REMARKS
A-608	AEROBIC LAGOON AERATOR	16	12,963	#/HR	(O_2 REQUIREMENT)				CS			$19,805	$316,884	1.40	$443,638	$316,884	$443,638	SCALED ON PLANT CAP, 0.51 FACTOR
C-601	LIGNIN WET CAKE CONVEYR	1	87,477	#/HR	200				CS			$19,118	$19,118	1.40	$26,765	$15,399	$21,559	PRICE INCLUDES C-601A&B
C-601A&B	LIGNIN CAKE TRANS. CONV.	2	29,159	#/HR	30				CS			$3,353	$6,707	1.40	$9,389	$0	$0	CONVEYORS FEED C-601
C-614	AEROBIC SLUDGE CONVEYR	1	862	#/HR	25				CS			$2,890	$2,890	1.40	$4,046	$2,654	$3,716	
M-604	NUTRIENT FEED SYSTEM	1		#/HR					CS			$31,400	$31,400	2.58	$81,012	$31,400	$81,012	NOT SCALED
M-606	BIOGAS HANDLING SYSTEM	1	670	SCFM					304L SS			$12,135	$12,135	1.68	$20,387	$12,135	$20,387	SCALED ON FLOW, 0.6 FACTOR
M-612	FILTER PRECOAT SYSTEM	1		#/HR					CS			$3,000	$3,000	1.40	$4,200	$3,000	$4,200	NOT SCALED
S-600	BAR SCREEN	1	165,901	#/HR					CS			$88,227	$88,227	1.20	$105,872	$88,227	$105,872	SCALED ON FLOW, 0.3 FACTOR
S-601	BC BTMS CENTRIFUGE	3	162	GPM				212	316L SS			$370,938	$1,112,814	1.20	$1,335,377	$1,112,814	$1,335,377	SCALED ON FLOW, 0.6 FACTOR
S-614	AER. SLUDGE FILTER PRESS	1	163,832	#/HR					304L SS			$341,246	$341,246	1.80	$614,243	$341,246	$614,243	SCALED ON FLOW, 0.72 FACTOR
SUBTOTAL	OTHER EQUIPMENT	28								0			$1,934,421	1.37	$2,644,929	$1,923,760	$2,630,004	

C-601A&B
INC W/P-601

AREA 600			DELTA T EST (97)	
EQUIP	INST FACT	INST COST	SCALED 97	INST COST
$3,351,109	**1.35**	**$4,538,844**	**$3,280,923**	**$4,400,219**

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Hastings, NE
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AREA: 700 - STORAGE
PFD: D-700-N-A701

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EQUIPMENT GROUP: PUMPS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO.	CAPACITY GALS/MIN	SIZE (IN) SUCT	SIZE (IN) DISCH	SIZE (IN) IMP	PRESS FEET	D.TEMP °F	MATL	MOTOR HP	MOTOR RPM	VB COST ESTIMATE $ / ITEM	VB COST ESTIMATE TOTAL $	VB COST ESTIMATE INST FACT	VB COST ESTIMATE INSTALLED	DELTA T ESTIMATE SCALED 97	DELTA T ESTIMATE INSTALLED	REMARKS
P-701	ETHANOL PRODUCT PUMP	3	130					250	316 SS		1750	$6,630	$19,891	2.80	$55,695	$10,914	$30,558	
P-703	SULFURIC ACID PUMP	2	86					250	CS		1750	$5,223	$10,446	2.80	$29,249	$8,564	$23,980	
P-704	FIREWATER PUMP	2	500					250	316 SS		1750	$9,112	$18,224	2.80	$51,027	$17,849	$49,976	
P-706	AMMONIA PUMP	2	4					250	CS		1750	$3,172	$6,345	2.80	$17,765	$5,615	$15,723	
P-707	ANTIFOAM PUMP	2	0.4					250	CS		1750	$3,094	$6,187	2.80	$17,325	$5,526	$15,473	
P-708	DIESEL PUMP	2	12					250	CS		1750	$3,381	$6,763	2.80	$18,936	$5,916	$16,565	
P-710	GASOLINE PUMP	2	7					250	CS		1750	$3,252	$6,504	2.80	$18,211	$4,283	$11,992	
P-720	CSL PUMP	2	173					250	CS		1750	$5,536	$11,072	2.80	$31,001	$8,329	$23,322	
SUBTOTAL	PUMPS	17								0			$85,431	2.80	$239,208	$66,996	$187,588	

EQUIPMENT GROUP: TANKS/VESSELS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO:	CAPACITY GALLONS	SIZE (FT) DIA	SIZE (FT) S.SIDE		PRESS PSIG	D.TEMP °F	MATL	DESIGN CODE DESIGN	DESIGN CODE NO.	VB COST ESTIMATE $ / ITEM	VB COST ESTIMATE TOTAL $	VB COST ESTIMATE INST FACT	VB COST ESTIMATE INSTALLED	DELTA T ESTIMATE SCALED 97	DELTA T ESTIMATE INSTALLED	REMARKS
T-701	ETH. PRODUCT STORAGE	2	241,621	35	33		ATM	212	CS	API	FL ROOF	$115,744	$231,488	1.40	$324,084	$207,856	$290,999	
T-703	SULFURIC ACID STORAGE	1	7,478	10	12		ATM	212	316 SS	API	650	$28,390	$28,390	1.20	$34,067	$28,390	$34,067	SCALED ON VOLUME, 0.51 FACTOR
T-704	FIREWATER STORAGE TANK	1	239,968	35	33		ATM	212	CS	API	650	$96,146	$96,146	1.40	$134,604	$104,122	$145,770	
T-706	AMMONIA STORAGE TANK	1	22,997	16	14		200/FV	400	A515	ASME	VIII-1	$169,792	$169,792	1.40	$237,709	$169,792	$237,709	SCALED ON VOLUME, 0.72 FACTOR
T-707	ANTIFOAM STORAGE TANK	1	4,799	10	9		ATM	212	CS	API	650	$12,006	$12,006	1.40	$16,809	$7,512	$10,516	
T-708	DIESEL STORAGE TANK	1	4,266	9	9		ATM	212	CS	API	650	$11,805	$11,805	1.40	$16,527	$9,024	$12,634	
T-710	GASOLINE STORAGE TANK	1	25,434	17	14		ATM	212	CS	API	FL ROOF	$23,734	$23,734	1.40	$33,227	$26,933	$37,706	
T-720	CSL STORAGE TANK	1	28,763	18	14		ATM	212	304 SS	API	650	$50,021	$50,021	1.40	$70,029	$41,694	$58,372	
SUBTOTAL	TANKS/VESSELS	9											$623,381	1.39	$867,055	$595,322	$827,774	

EQUIPMENT GROUP: MISCELLANEOUS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO:	CAPACITY	UNITS				DESIGN PSIG	DESIGN °F	MATL	MOTOR HP	VB COST ESTIMATE $ / ITEM	VB COST ESTIMATE TOTAL $	VB COST ESTIMATE INST FACT	VB COST ESTIMATE INSTALLED	DELTA T ESTIMATE SCALED 97	DELTA T ESTIMATE INSTALLED	REMARKS
A-701	ETH. DENATURANT MIXER	1	13	#/HR					304L SS			$1,223	$1,223	1.00	$1,223	$1,223	$1,223	SCALED ON FLOW, 0.48 FACTOR
SUBTOTAL	OTHER EQUIPMENT	1											$1,223	1.00	$1,223	$1,223	$1,223	

AREA 700			DELTA T EST (97)	
EQUIP	INST FACT	INST COST	SCALED 97	INST COST
$710,036	**1.56**	**$1,107,487**	**$663,541**	**$1,016,585**

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PFD: D-800-N-A801/A802/A803

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EQUIPMENT GROUP: EXCHANGERS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO.	CAPACITY MM BTU/HR	SIZE TYPE	SIZE SQFT	SIZE U VAL	DESIGN PRESS SHELL	DESIGN PRESS TUBE	D.TEMP °F	MATERIALS SHELL	MATERIALS TUBE	VB COST ESTIMATE $ / ITEM	VB COST ESTIMATE TOTAL $	VB COST ESTIMATE INST FACT	VB COST ESTIMATE INSTALLED	DELTA T ESTIMATE SCALED 97	DELTA T ESTIMATE INSTALLED	REMARKS
H-811	BFW PREHEATER	1		NEN	200		100	100	250	304L SS	304L SS	$14,333	$14,333	2.10	$30,099	$31,968	$67,132	
SUBTOTAL	EXCHANGERS	1											$14,333	2.10	$30,099	$31,968	$67,132	

EQUIPMENT GROUP: PUMPS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO.	CAPACITY GALS/MIN	SIZE (IN) SUCT	SIZE (IN) DISCH	SIZE (IN) IMP	PRESS FEET	D.TEMP °F	MATL	MOTOR HP	MOTOR RPM	VB COST ESTIMATE $ / ITEM	VB COST ESTIMATE TOTAL $	VB COST ESTIMATE INST FACT	VB COST ESTIMATE INSTALLED	DELTA T ESTIMATE SCALED 97	DELTA T ESTIMATE INSTALLED	REMARKS
P-804	CONDENSATE PUMP	2	109					212	316 SS		1750	$6,491	$12,982	2.80	$36,349	$13,581	$38,028	
P-811	TURBINE CONDENSATE PUMP	2	70					212	316 SS		1750	$6,031	$12,062	2.80	$33,774	$9,892	$27,697	
P-824	DEAERATOR FEED PUMP	2	260					212	316 SS		1750	$7,504	$15,008	2.80	$42,022	$7,244	$20,283	
P-826	BFW PUMP	5	200					212	316 SS		1750	$7,102	$35,510	2.80	$99,428	$65,283	$182,792	
P-828	BLOWDOWN PUMP	2	12					212	CS		1750	$3,371	$6,743	2.80	$18,880	$5,333	$14,933	
P-830	HYDRAZINE TRANSFR PUMP	1	2					212	CS		1750	$3,132	$3,132	2.80	$8,771	$2,787	$7,802	
SUBTOTAL	PUMPS	14								0			$85,437	2.80	$239,225	$104,120	$291,535	

EQUIPMENT GROUP: TANKS/VESSELS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO:	CAPACITY GALLONS	SIZE (FT) DIA	SIZE (FT) S.SIDE	PRESS PSIG	D.TEMP °F	MATL	DESIGN CODE DESIGN	DESIGN CODE NO.	VB COST ESTIMATE $ / ITEM	VB COST ESTIMATE TOTAL $	VB COST ESTIMATE INST FACT	VB COST ESTIMATE INSTALLED	DELTA T ESTIMATE SCALED 97	DELTA T ESTIMATE INSTALLED	REMARKS
T-804	CONDENSATE COLLECTOR	1	640	4.3	5.8	ATM	212	CS	API	620	$7,590	$7,590	1.40	$10,627	$2,682	$3,755	
T-824	CONDENSATE SURGE DRUM	1	4,559	8.8	10.1	100/FV	400	304 SS	ASME	VIII-1	$37,743	$37,743	1.70	$64,163	$25,161	$42,774	
T-826	DEAERATOR	1	7,267	10.3	11.6	200/FV	400	304 SS	ASME	VIII-1	$66,967	$66,967	2.80	$187,508	$79,762	$223,333	
T-828	BLOWDOWN FLASH DRUM	1	170	2.8	3.6	100/FV	400	CS	ASME	VIII-1	$7,182	$7,182	2.80	$20,109	$5,122	$14,343	
T-830	HYDRAZINE DRUM	1	104	2.5	2.9	100/FV	400	304 SS	ASME	VIII-1	$9,525	$9,525	1.70	$16,193	$5,569	$9,468	
SUBTOTAL	TANKS/VESSELS	5										$129,008	2.31	$298,600	$118,297	$293,672	

EQUIPMENT GROUP: MISCELLANEOUS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO:	CAPACITY	CAPACITY UNITS	CAPACITY	CAPACITY UNITS	DESIGN PSIG	DESIGN °F	MATL	MOTOR HP	MOTOR RPM	VB COST ESTIMATE $ / ITEM	VB COST ESTIMATE TOTAL $	VB COST ESTIMATE INST FACT	VB COST ESTIMATE INSTALLED	DELTA T ESTIMATE SCALED 97	DELTA T ESTIMATE INSTALLED	REMARKS
M-801	SOLID FEED ROTARY DRYER	1	39,311	#/HR					304L SS			$1,073,849	$1,073,849	1.60	$1,718,159	$1,073,849	$1,718,159	SCALED ON FLOW, 0.45 FACTOR
M-803	FL BED COMBUST. REACTOR	1	39,583	#/HR					304L SS			$9,473,638	$9,473,638	1.30	$12,315,729	$9,473,638	$12,315,729	SCALED ON FLOW, 0.75 FACTOR
M-804	COMBUST. GAS BAGHOUSE	1	218,000	SCFM					304L SS			$623,674	$623,674	1.50	$935,511	$623,674	$935,511	SCALED ON FLOW, 0.58 FACTOR
M-811	TURBINE/GENERATOR	1	247,800	#/HR	STEAM				304L SS			$4,596,447	$4,596,447	1.50	$6,894,671	$4,596,447	$6,894,671	SCALED ON FLOW, 0.71 FACTOR
M-820	WATER SOFTENER SYSTEM	1	400	GPM	629491				304L SS			$629,491	$629,491	1.30	$818,338	$629,491	$818,338	SCALED ON FLOW, 0.82 FACTOR
M-830	HYDRAZINE ADD'N PACKAGE	1							304L SS			$11,337	$11,337	1.00	$11,337	$11,337	$11,337	SCALED ON FLOW, 0.6 FACTOR
M-832	AMMONIA ADD'N PACKAGE	1							304L SS			$11,337	$11,337	1.00	$11,337	$11,337	$11,337	SCALED ON FLOW, 0.6 FACTOR
M-834	PHOSPHATE ADD'N PACKAGE	1							304L SS			$11,337	$11,337	1.00	$11,337	$11,337	$11,337	SCALED ON FLOW, 0.6 FACTOR
SUBTOTAL	OTHER EQUIPMENT	8								0			$16,431,110	1.38	$22,716,418	$16,431,110	$22,716,418	

AREA 800			DELTA T EST (97)	
EQUIP	INST FACT	INST COST	SCALED 97	INST COST
$16,659,888	1.40	$23,284,342	$16,685,494	$23,368,758

EQUIPMENT LIST

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Hastings, NE
PROJ: **9827**
AREA: 900 - UTILITIES
PFD: D-900-N-A901/A902/A903

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EQUIPMENT GROUP: PUMPS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO.	CAPACITY GALS/MIN	SIZE (IN) SUCT	SIZE (IN) DISCH	SIZE (IN) IMP	PRESS FEET	D.TEMP °F	MATL	MOTOR HP	MOTOR RPM	VB COST ESTIMATE $ / ITEM	VB COST ESTIMATE TOTAL $	VB COST ESTIMATE INST FACT	VB COST ESTIMATE INSTALLED	DELTA T ESTIMATE SCALED 97	DELTA T ESTIMATE INSTALLED	REMARKS
P-902	COOLING WATER PUMP	2	16,400					212	CS		1750	$129,278	$258,556	2.80	$723,956	$258,556	$723,956	SCALED TO FLOW, 0.79 FACTOR
P-912	MAKE-UP WATER PUMP	2	433					212	CS		1750	$6,932	$13,863	2.80	$38,817	$8,433	$23,612	
P-914	PROCESS WTR CIRC. PUMP	3	480					212	CS		1750	$7,182	$21,547	2.80	$60,332	$13,240	$37,073	
SUBTOTAL	PUMPS	7								0			$293,966	2.80	$823,105	$280,229	$784,641	

EQUIPMENT GROUP: TANKS/VESSELS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO.	CAPACITY GALLONS	SIZE (FT) DIA	SIZE (FT) S.SIDE		PRESS PSIG	D.TEMP °F	MATL	DESIGN CODE DESIGN	DESIGN CODE NO.	VB COST ESTIMATE $ / ITEM	VB COST ESTIMATE TOTAL $	VB COST ESTIMATE INST FACT	VB COST ESTIMATE INSTALLED	DELTA T ESTIMATE SCALED 97	DELTA T ESTIMATE INSTALLED	REMARKS
T-904	PLANT AIR RECEIVER	1	376	4	5		100/FV	400	CS	ASME	VIII-1	$8,845	$8,845	1.30	$11,499	$6,721	$8,737	
T-914	PROCESS WATER TANK	1	300,021	39	33		ATM	212	CS	API	650	$107,334	$107,334	1.40	$150,268	$107,788	$150,903	
SUBTOTAL	TANKS/VESSELS	2											$116,179	1.39	$161,767	$114,509	$159,640	

EQUIPMENT GROUP: MISCELLANEOUS

EQUIP NUMBER	EQUIPMENT DESCRIPTION NAME	NO.	CAPACITY	UNITS			DESIGN PSIG	DESIGN °F	MATL	MOTOR HP	MOTOR RPM	VB COST ESTIMATE $ / ITEM	VB COST ESTIMATE TOTAL $	VB COST ESTIMATE INST FACT	VB COST ESTIMATE INSTALLED	DELTA T ESTIMATE SCALED 97	DELTA T ESTIMATE INSTALLED	REMARKS
M-902	COOLING TOWER	1	32,509	GPM				FIBERGLASS				$672,523	$672,523	1.20	$807,027	$672,523	$807,027	SCALED TO FLOW, 0.78 FACTOR
M-904	PLANT AIR COMPRESSOR	3	180	CFM					CS			$44,012	$132,036	1.30	$171,647	$132,036	$171,647	SCALED TO FLOW, 0.34 FACTOR
M-908	CHILLED WATER PACKAGE	3	1,200	TONS (REFRIGERANT)					CS			$176,811	$530,434	1.20	$636,521	$530,434	$636,521	SCALED TO FLOW, 0.8 FACTOR
M-910	CIP SYSTEM	1							CS			$54,843	$54,843	1.20	$65,812	$54,843	$65,812	SCALED TO FLOW, 0.6 FACTOR
S-904	INSTRUMENT AIR DRYER	2	160	CFM					CS			$7,584	$15,167	1.30	$19,718	$15,167	$19,718	SCALED TO FLOW, 0.78 FACTOR
SUBTOTAL	OTHER EQUIPMENT	10											$1,405,004	1.21	$1,700,725	$1,405,004	$1,700,725	

AREA 900			DELTA T EST (97)	
EQUIP	INST FACT	INST COST	SCALED 97	INST COST
$1,815,149	**1.48**	**$2,685,596**	**$1,799,741**	**$2,645,006**

Financial Evaluation of a Biomass-to-Ethanol Production Facility Located at Chief Ethanol Fuels in Hastings, Nebraska

Prepared by Vogelbusch U.S.A., Inc.
Houston, Texas
January 2000

for
National Renewable Energy Laboratory
Golden, Colorado

Preface

A financial analysis was prepared for the construction and long-term operation of a nominal 23,000,000 gallon per year fuel ethanol facility to be located adjacent to the Chief Ethanol Fuels facility in Hastings, Nebraska.

A “Base Case” evaluation, incorporating site specific capital costs, operating costs, feedstock costs, and final products market value is provided.

Also included is a “Target Case”, which makes the following adjustments to the “Base Case”:

- Ethanol yield from stover is increased 20%
- Delivered stover price is reduced by $10 per dry U.S. ton
- Chemical costs are reduced from $0.50 to $0.30 per anhydrous ethanol gallon
- Installed cost of the facility is reduced from $6.22 to $3.00 per annual gallon
- Loan interest rate reduced from 10% to the current prime lending rate of 8.5%

Each analysis consists of the following:

- Sources and Application of Funds (Year 1)
- Sources and Application of Funds (Year 2)
- Balance Sheet (Years 1 through 12)
- Income Statement (Years 1 through 12)
- Cash Flow Statement (Years 1 through 12)
- Pricing Sensitivity Matrix - Average Annual Pre-tax Income (Years 3 through 12)
- Pricing Sensitivity Matrix - Average Annual Cash Flow (Years 3 through 12)

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Financial Evaluation of a Biomass-to-Ethanol Production Facility Located at Chief Ethanol Fuels in Hastings, Nebraska

Plant Design Capacity

The projections presented are for a facility that will produce a nominal 23,000,000 gallons per year of fuel-grade ethanol from corn stover.

Product yields are based on the following conversion rates:

Ethanol	60.67 anhydrous gallons per U.S. ton corn stover (16% moisture)
	72.23 anhydrous gallons per U.S. ton corn stover (dry basis)
Carbon dioxide	0.193 tons per U.S. ton corn stover (16% moisture)
	0.229 tons per U.S. ton corn stover (dry basis)
Electricity	65.22 kilowatts per U.S. ton corn stover (16% moisture)
	77.64 kilowatts per U.S. ton corn stover (dry basis)

The annual design production capacity of the plant is as follows:

Fuel grade ethanol	23,465,805 gallons
Carbon dioxide	70,796 U.S. tons
Electricity	11,982 kilowatts

Corn stover consumption is estimated at 367,439 U.S. tons annually, based on a moisture content of 16%. This equates to 308,649 U.S. tons (dry basis).

Annual production and consumption rates are based on 350 operating days per year, allowing 15 days for scheduled and unscheduled maintenance and cleaning.

Project Cost

Based on our extensive experience and equipment database along with prices and cost factors provided by NREL in Technical Report NREL/TP-580-26157, the total installed plant cost was estimated at $138,598,690.

A detailed capital cost estimate is provided on the following page.

The total estimated project cost includes working capital and reserves equal to 10% of the estimated installed plant cost:

Capital Improvements	$138,598,690
Working Capital & Reserves	$13,859,869
Total	**$152,458,559**

CAPITAL COST DETAIL

NREL - Biomass to Ethanol Facility at Chief Ethanol Fuels — BASE CASE

AREA NO.	AREA DESCRIPTION	EQUIP COST	ERECTION,PIPING,INSULATION		ELECTRICAL & CONTROLS		CONCRETE & STRUCTURAL		TOTAL COST
			FACTOR	COST	FACTOR	COST	FACTOR	COST	
000	SITE & BUILDINGS	$450,000	0.00	$0	0.00	$0	0.00	$0	**$450,000**
100	FEED HANDLING	$5,104,172	0.32	$1,633,335	0.30	$1,531,252	0.40	$2,041,669	**$10,310,427**
200	PREPARATION	$9,808,335	0.57	$5,590,751	0.30	$2,942,501	0.50	$4,904,168	**$23,245,754**
300	FERMENTATION	$6,672,629	0.61	$4,070,304	0.30	$2,001,789	0.20	$1,334,526	**$14,079,247**
500	DISTIL/EVAP/MOLSIEVE	$5,433,500	0.68	$3,694,780	0.40	$2,173,400	0.40	$2,173,400	**$13,475,080**
600	W WATER TREATMENT	$3,351,109	0.30	$1,005,333	0.20	$670,222	1.00	$3,351,109	**$8,377,773**
700	ALCOHOL STORAGE & LO	$710,036	0.30	$213,011	0.25	$177,509	0.40	$284,014	**$1,384,570**
800	BOILER & BFW	$16,659,888	0.40	$6,663,955	0.40	$6,663,955	0.40	$6,663,955	**$36,651,754**
900	COOLING TOWER	$1,815,149	0.40	$726,060	0.30	$544,545	0.30	$544,545	**$3,630,298**
3000	DCS (COMPUTER)	$596,602	0.10	$59,660	0.50	$298,301	0.40	$238,641	**$1,193,204**
TOTAL FOR ALL AREAS		**$50,601,419**	**0.468**	**$23,657,188**	**0.336**	**$17,003,473**	**0.426**	**$21,536,026**	**$112,798,107**

INSTALLED COST

INSTALLED ESTIMATE ABOVE		**$112,798,107**
CONTINGENCY	**10.00%**	**$11,279,811**
TOTAL INSTALLED COST		**$124,077,918**

PROCESS ENGINEERING (VOGELBUSCH)

ENGINEERING, KNOW-HOW & STARTUP FEE (TYPICAL)	**$985,000**

DETAILED ENGINEERING & CONSTRUCTION OVERHEAD

PERCENTAGE OF INSTALLED COST -	**12.00%**	**$13,535,773**

TOTAL CAPITAL COST ESTIMATE **$138,598,690**

Project Financing

It is assumed that the project is funded with an equity participation of 30% of the total project cost. This represents a 2.33 to 1 debt-to-equity ratio.

The following details the anticipated funding sources for the project:

Project Financing (Term Loan)	$106,720,992
Equity	$ 45,737,568
Total	**$152,458,560**

It is assumed that the project will be financed with a $106,720,992 loan bearing a fixed interest rate of 10% over a 15-year term and structured so that interest only is paid on the note balance during years 1 and 2. In year 3, full amortization begins with a total annual debt service of $14,031,012, including both principal and interest.

Detail of debt service is shown on the following page.

DEBT SERVICE

NREL - Biomass to Ethanol Facility at Chief Ethanol Fuels **BASE CASE**

DEBT SERVICE	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10	YEAR 11	YEAR 12
Total Plant Debt Balance	52,583,939	106,720,992	103,362,079	99,667,275	95,602,991	91,132,278	86,214,494	80,804,931	74,854,413	68,308,842	61,108,714	53,188,574
Interest Payment	2,076,188	8,334,972	10,672,099	10,336,208	9,966,727	9,560,299	9,113,228	8,621,449	8,080,493	7,485,441	6,830,884	6,110,871
Principal Payment			3,358,913	3,694,804	4,064,284	4,470,713	4,917,784	5,409,562	5,950,519	6,545,571	7,200,128	7,920,140

Beginning Debt	106,720,992
Interest Rate	10.00%
Payments	15
Annual Debt Service Payment	14,031,012

Construction and Startup Timetable

The facility is to be constructed over an 18-month period.

After construction is complete, the plant will be started in month 19, when it is expected to achieve an overall production rate of 30% of rated capacity. It is assumed that production in month 20 will be 70% of rated capacity with full rated capacity anticipated for month 21.

Draw Down Schedule

The projections are based on a construction draw down schedule that ties progress payments to construction progress. It is anticipated that construction funds will be drawn, as follows:

Month 1	30.00%	$41,579,607
Months 2 - 19	3.33%	$4,619,956/month
Month 20	10.00%	$13,859,875
TOTAL	**100%**	**$138,598,690**

Depreciation and Amortization

The projections anticipate that the term loan will be fully amortized over a 15-year period.

Interest paid during construction on the draw down of the available credit line is capitalized and added to the cost of the plant. The following details the estimated total plant cost:

Capital Improvements	$138,598,690
Capitalized Interest	$ 5,364,104
Total Plant Cost	**$143,962,794**

Total plant cost of $143,962,794 is being depreciated using straight-line depreciation over the estimated life of the facility of 15 years, beginning in year 2.

(Note: According to Generally Accepted Accounting Principles (GAAP), depreciation for project feasibility projections is based on the estimated, useful life of the facility. In this case, a typical 15 years straight-line depreciation was used.)

The project will incur fees to the lenders. It is anticipated that these fees will equal 2% of the financing amount or $2,134,420. The anticipated bank fees are capitalized and amortized on a straight-line basis over a 15-year period, beginning in year 1.

Expenses incurred prior to startup of the plant have been capitalized as organizational expenses. These expenses are estimated at $2,820,645 and will be amortized on a straight-line basis over a 5-year period beginning in year 2 (as per GAAP).

Details of depreciation and amortization calculations are provided on the following page.

DEPRECIATION CALCULATIONS

NREL - Biomass to Ethanol Facility at Chief Ethanol Fuels **BASE CASE**

DEPRECIATION CALCULATIONS	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10	YEAR 11	YEAR 12
Plant Cost	94,424,491	143,962,794	143,962,794	143,962,794	143,962,794	143,962,794	143,962,794	143,962,794	143,962,794	143,962,794	143,962,794	143,962,794
Annual depreciation-percentage		6.67%	6.67%	6.67%	6.67%	6.67%	6.67%	6.67%	6.67%	6.67%	6.67%	6.67%
Annual depreciation-dollars	**0**	**9,597,520**	**9,597,520**	**9,597,520**	**9,597,520**	**9,597,520**	**9,597,520**	**9,597,520**	**9,597,520**	**9,597,520**	**9,597,520**	**9,597,520**
Cumulative depreciation	0	9,597,520	19,195,040	28,792,560	38,390,080	47,987,600	57,585,120	67,182,640	76,780,160	86,377,680	95,975,200	105,572,720
Net plant value	94,424,491	134,365,274	124,767,754	115,170,234	105,572,714	95,975,194	86,377,674	76,780,154	67,182,634	57,585,114	47,987,594	38,390,074
Loan Fees	2,134,420	2,134,420	2,134,420	2,134,420	2,134,420	2,134,420	2,134,420	2,134,420	2,134,420	2,134,420	2,134,420	2,134,420
Annual amortization-percentage	6.67%	6.67%	6.67%	6.67%	6.67%	6.67%	6.67%	6.67%	6.67%	6.67%	6.67%	6.67%
Annual amortization-dollars	**142,295**	**142,295**	**142,295**	**142,295**	**142,295**	**142,295**	**142,295**	**142,295**	**142,295**	**142,295**	**142,295**	**142,295**
Cumulative amortization	142,295	284,589	426,884	569,179	711,473	853,768	996,063	1,138,357	1,280,652	1,422,947	1,565,241	1,707,536
Net loan fees	1,992,125	1,849,831	1,707,536	1,565,241	1,422,947	1,280,652	1,138,357	996,063	853,768	711,473	569,179	426,884
Start up expenses	1,752,596	2,820,645	2,820,645	2,820,645	2,820,645	2,820,645	2,820,645	2,820,645	2,820,645	2,820,645	2,820,645	2,820,645
Annual amortization-percentage		20.00%	20.00%	20.00%	20.00%	20.00%						
Annual amortization-dollars	**0**	**564,129**	**564,129**	**564,129**	**564,129**	**564,129**						
Cumulative amortization	0	564,129	1,128,258	1,692,387	2,256,516	2,820,645	2,820,645	2,820,645	2,820,645	2,820,645	2,820,645	2,820,645
Net start up expenses	1,752,596	2,256,516	1,692,387	1,128,258	564,129	0						

Accounts Receivable and Inventories

Accounts receivable are estimated to climb as sales increase until they stabilize at 30 days sales. Normal industry terms are net 30. Accounts receivable will equal an investment of $2,248,807.

There has been no provision for uncollectable accounts.

Inventories are projected to rise as the plant comes on stream, with raw materials equaling five days of production, work in progress anticipated to equal two days of production, and finished goods estimated at three days. Details of inventories are as follows:

Raw Material Inventory	5 days	$186,035
Work in Progress	2 days	$ 74,414
Finished Goods	3 days	$221,800
Total Inventory		**$482,249**

All inventory and accounts receivable values have been inflated at a rate of 2% per year, starting in year 3.

Accounts Payable

Accounts payable are estimated to be paid on a net 30 basis, except for items which, contractually, are to be paid on different terms and payroll, which is projected on a cash basis.

In order to be conservative in projecting cash flow, no provision for accounts payable is shown in the projections.

Product Sales and Raw Material Costs

The proforma financial statements reflect the following prices for products and raw material:

Corn Stover	$44.00/U.S. ton (dry basis)
	$36.90/ U.S. ton (16% moisture)
Fuel Ethanol	$1.15/gallon

No provision for sale of carbon dioxide has been made in the financial projections.

Maintenance and Operating Costs

Maintenance costs include the equipment and supplies necessary for keeping the plant equipment in operating order and are estimated to be approximately 1.0% of the Capital Improvements costs. This corresponds with costs at similar facilities.

The following costs were used to determine variable operating costs for the proposed facility:

Corn Stover	$44.00/U.S. ton (dry basis)
Chemicals	various current prices
Enzymes	$1.00/pound
Water	$1.00/1000 gal
Disposal	$20.00/ton
Natural Gas	$2.50/MMBTU

Maintenance and operating costs per anhydrous ethanol gallon produced are, as follows:

Corn Stover	$0.6092
Chemicals and Enzymes	$0.5022
Water	$0.0086
Disposal	$0.0118
Natural Gas	$0.0360
Maintenance	$0.0622

A detailed breakdown of raw material usage and costs is provided on the following page.

All costs have been inflated at a rate of 2% per year, starting in year 4.

RAW MATERIAL DETAIL

NREL - Biomass to Ethanol Facility at Chief Ethanol Fuels — BASE CASE

RAW MATERIAL	USAGE			COST				
	LB/HR	LB/YR	LB/GAL*	$	UNIT	$/LB	$/YR	$/GAL*
Corn Stover	87,485	734,877,678	32.9652	$36.96	US ton	$0.01848	**$13,580,539**	**$0.6092**
Corn Stover (steam)	0	0	0.0000	$36.96	US ton	$0.01848	**$0**	**$0.0000**
Corn Steep Liquor	1,362	11,440,800	0.5132	$0.075	lb	$0.07500	$858,060	$0.0385
Sulfuric Acid	1,647	13,834,800	0.6206	$86.20	US ton	$0.04310	$596,280	$0.0267
Cellulase	796	6,686,400	0.2999	$1.000	lb	$1.00000	$6,686,400	$0.2999
Lime	629	5,283,600	0.2370	$70.00	US ton	$0.03500	$184,926	$0.0083
Ammonia	1,242	10,432,800	0.4680	$260.00	US ton	$0.13000	$1,356,264	$0.0608
Nutrients	164	1,378,964	0.0619	$0.124	lb	$0.12400	$170,991	$0.0077
Ammonium Sulfate	370	3,106,631	0.1394	$132.00	US ton	$0.06600	$205,038	$0.0092
Antifoam (Corn Oil)	0	0	0.0000	$0.249	lb	$0.24900	$0	$0.0000
Gasoline	838	7,039,200	0.3158	$0.600	gal	$0.09734	$685,169	$0.0307
Diesel	391	3,284,400	0.1473	$0.600	gal	$0.05880	$193,123	$0.0087
BFW Chemicals	0.42	3,535	0.0002	$0.97	lb	$0.97000	$3,429	$0.0002
CW Chemicals	5	39,625	0.0018	$1.00	lb	$1.00000	$39,625	$0.0018
WWT Nutrients	217	1,822,768	0.0818	$0.11	lb	$0.11000	$200,504	$0.0090
WWT Chemicals	0.72	6,023	0.0003	$2.50	lb	$2.50000	$15,058	$0.0007
CHEMICALS TOTAL							**$11,194,867**	**$0.5022**
Make-up Water	190,296	1,598,485,528	71.7050	$0.001	gal	$0.00012	**$191,895**	**$0.0086**
Ash Disposal	974	8,181,600	0.3670	$20.00	US ton	$0.01000	$81,816	$0.0037
Gypsum Disposal	2,146	18,026,400	0.8086	$20.00	US ton	$0.01000	$180,264	$0.0081
DISPOSAL TOTAL							**$262,080**	**$0.0118**

* Raw material usage and cost is per anhydrous alcohol gallon produced

Plant Labor, Plant Management, and Administrative Costs

Salaries and wages required to operate and maintain the facility are included in the plant operating expenses. Because the proposed facility will be part of an existing production facility, the new addition will be able to take advantage of much of the administrative, production, and maintenance system already in place. As a result plant labor, plant management, and administrative costs are expected to be significantly less than a stand-alone facility.

It is estimated that the plant operations will employ 28 persons when the facility achieves full production. Total annual compensation, including 30% for benefits, is estimated to be $981,500 in year 3 and is adjusted annually by increasing this cost by 2% per year.

It is also estimated that the organization will also require an accountant to perform the additional administrative duties associated with the new facility. Total annual compensation, including 30% for benefits, is anticipated to be $78,000 in year 3 and is adjusted annually by increasing this cost by 2% per year.

Details of both plant and administrative personnel is provided on the next four pages in the following spreadsheets:

- Personnel Detail
- Salaries, Wages, and Benefits by Job Classification - Year 1 Details
- Salaries, Wages, and Benefits by Job Classification - Year 2 Details
- Salaries, Wages, and Benefits by Job Classification

PERSONNEL DETAIL

NREL - Biomass to Ethanol Facility at Chief Ethanol Fuels **BASE CASE**

PLANT PERSONNEL	Rate	Hourly/ Salaried	Annual Hours	Annual Comp.	Number	Base Comp.	30% Benefits	Annual Total
Operations								
Management								
Plant Manager	80,000	S		80,000	0	0	0	0
Production Manager	65,000	S		65,000	1	65,000	19,500	84,500
Professional								
Lab Manager	50,000	S		50,000	0	0	0	0
Supervisory								
Shift Supervisor	16.17	H	2,288	37,000	4	148,000	44,400	192,400
Maintenance Supervisor	17.79	H	2,080	37,000	0	0	0	0
Administrative Supervisor	16.35	H	2,080	34,000	0	0	0	0
Direct Labor								
Operators	10.93	H	2,288	25,000	8	200,000	60,000	260,000
Indirect Labor								
Maintenance Technicians	13.46	H	2,080	28,000	4	112,000	33,600	145,600
Laboratory Technicians	10.93	H	2,288	25,000	2	50,000	15,000	65,000
Shipping/Receiving Clerk	9.62	H	2,080	20,000	1	20,000	6,000	26,000
Administrative Clerks	9.62	H	2,080	20,000	0	0	0	0
Yard	9.62	H	2,080	20,000	8	160,000	48,000	208,000
			Total Employment:		**28**	**Total Compensation:**		**$981,500**

ADMINISTRATIVE PERSONNEL	Rate	Hourly/ Salaried	Annual Hours	Annual Comp.	Number	Base Comp.	30% Benefits	Annual Total
Administration								
Management								
General Manager	100,000	S		100,000	0	0	0	0
Marketing Manager	60,000	S		60,000	0	0	0	0
Accountant	60,000	S		60,000	1	60,000	18,000	78,000
Professional								
Plant Engineer	65,000	S		65,000	0	0	0	0
Other								
Secretary/Receptionist	9.62	H	2,080	20,000	0	0	0	0
Bookkeeper	9.62	H	2,080	20,000	0	0	0	0
			Total Employment:		**1**	**Total Compensation:**		**$78,000**

SALARIES, WAGES, AND BENEFITS BY JOB CLASSIFICATION
YEAR 1 DETAILS

NREL - Biomass to Ethanol Facility at Chief Ethanol Fuels **BASE CASE**

PLANT SALARIES, WAGES, AND BENEFITS BY JOB CLASSIFICATION - YEAR 1 DETAILS	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11	Month 12	Total
Operations													
Management													
Plant Manager					0	0	0	0	0	0	0	0	0
Production Manager													0
Professional													
Lab Manager										0	0	0	0
Supervisory													
Shift Supervisor													0
Maintenance Supervisor										0	0	0	0
Administrative Supervisor											0	0	0
Direct Labor													
Operators													0
Indirect Labor													
Maintenance Technicians													0
Laboratory Technicians													0
Shipping/Receiving Clerk													0
Administrative Clerks												0	0
Yard													0
TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0

ADMINISTRATIVE SALARIES, WAGES, AND BENEFITS BY JOB CLASSIFICATION - YEAR 1 DETAILS	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11	Month 12	Total
Administration													
Management													
General Manager	0	0	0	0	0	0	0	0	0	0	0	0	0
Marketing Manager	0	0	0	0	0	0	0	0	0	0	0	0	0
Accountant	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	78,000
Professional													
Plant Engineer	0	0	0	0	0	0	0	0	0	0	0	0	0
Other													
Secretary/Receptionist	0	0	0	0	0	0	0	0	0	0	0	0	0
Bookkeeper	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	78,000

SALARIES, WAGES, AND BENEFITS BY JOB CLASSIFICATION
YEAR 2 DETAILS

NREL - Biomass to Ethanol Facility at Chief Ethanol Fuels **BASE CASE**

PLANT SALARIES, WAGES, AND BENEFITS BY JOB CLASSIFICATION - YEAR 2 DETAILS	Month 13	Month 14	Month 15	Month 16	Month 17	Month 18	Month 19	Month 20	Month 21	Month 22	Month 23	Month 24	Total
Operations													
Management													
Plant Manager	0	0	0	0	0	0	0	0	0	0	0	0	0
Production Manager	7,042	7,042	7,042	7,042	7,042	7,042	7,042	7,042	7,042	7,042	7,042	7,042	84,504
Professional													
Lab Manager	0	0	0	0	0	0	0	0	0	0	0	0	0
Supervisory													
Shift Supervisor					16,033	16,033	18,438	16,033	16,033	16,033	16,033	16,033	130,669
Maintenance Supervisor	0	0	0	0	0	0	0	0	0	0	0	0	0
Administrative Supervisor	0	0	0	0	0	0	0	0	0	0	0	0	0
Direct Labor													
Operators					21,667	21,667	24,917	21,667	21,667	21,667	21,667	21,667	176,586
Indirect Labor													
Maintenance Technicians					12,133	12,133	13,953	12,133	12,133	12,133	12,133	12,133	98,884
Laboratory Technicians					5,417	5,417	6,230	5,417	5,417	5,417	5,417	5,417	44,149
Shipping/Receiving Clerk					2,167	2,167	2,384	2,167	2,167	2,167	2,167	2,167	17,553
Administrative Clerks	0	0	0	0	0	0	0	0	0	0	0	0	0
Yard					17,333	17,333	19,066	17,333	17,333	17,333	17,333	17,333	140,397
TOTAL	7,042	7,042	7,042	7,042	81,792	81,792	92,030	81,792	81,792	81,792	81,792	81,792	692,742

ADMINISTRATIVE SALARIES, WAGES, AND BENEFITS BY JOB CLASSIFICATION - YEAR 2 DETAILS	Month 13	Month 14	Month 15	Month 16	Month 17	Month 18	Month 19	Month 20	Month 21	Month 22	Month 23	Month 24	Total
Administration													
Management													
General Manager	0	0	0	0	0	0	0	0	0	0	0	0	0
Marketing Manager	0	0	0	0	0	0	0	0	0	0	0	0	0
Accountant	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	78,000
Professional													
Plant Engineer	0	0	0	0	0	0	0	0	0	0	0	0	0
Other													
Secretary/Receptionist	0	0	0	0	0	0	0	0	0	0	0	0	0
Bookkeeper	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	78,000

SALARIES, WAGES, AND BENEFITS BY JOB CLASSIFICATION

NREL - Biomass to Ethanol Facility at Chief Ethanol Fuels **BASE CASE**

PLANT SALARIES, WAGES, AND BENEFITS BY JOB CLASSIFICATION	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10	YEAR 11	YEAR 12
Operations												
Management												
Plant Manager	0	0	0	0	0	0	0	0	0	0	0	0
Production Manager	0	84,504	84,504	86,194	87,918	89,676	91,470	93,299	95,165	97,068	99,009	100,989
Professional												
Lab Manager	0	0	0	0	0	0	0	0	0	0	0	0
Supervisory												
Shift Supervisor	0	130,669	192,396	196,244	200,169	204,172	208,255	212,420	216,668	221,001	225,421	229,929
Maintenance Supervisor	0	0	0	0	0	0	0	0	0	0	0	0
Administrative Supervisor	0	0	0	0	0	0	0	0	0	0	0	0
Direct Labor												
Operators	0	176,586	260,004	265,204	270,508	275,918	281,436	287,065	292,806	298,662	304,635	310,728
Indirect Labor												
Maintenance Technicians	0	98,884	145,596	148,508	151,478	154,508	157,598	160,750	163,965	167,244	170,589	174,001
Laboratory Technicians	0	44,149	65,004	66,304	67,630	68,983	70,363	71,770	73,205	74,669	76,162	77,685
Shipping/Receiving Clerk	0	17,553	26,004	26,524	27,054	27,595	28,147	28,710	29,284	29,870	30,467	31,076
Administrative Clerks	0	0	0	0	0	0	0	0	0	0	0	0
Yard	0	140,397	207,996	212,156	216,399	220,727	225,142	229,645	234,238	238,923	243,701	248,575
TOTAL	0	692,742	981,504	1,001,134	1,021,156	1,041,579	1,062,411	1,083,659	1,105,331	1,127,437	1,149,984	1,172,983

ADMINISTRATIVE SALARIES, WAGES, AND BENEFITS BY JOB CLASSIFICATION	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10	YEAR 11	YEAR 12
Administration												
Management												
General Manager	0	0	0	0	0	0	0	0	0	0	0	0
Marketing Manager	0	0	0	0	0	0	0	0	0	0	0	0
Accountant	78,000	78,000	78,000	79,560	81,151	82,774	84,429	86,118	87,840	89,597	91,389	93,217
Professional												
Plant Engineer	0	0	0	0	0	0	0	0	0	0	0	0
Other												
Secretary/Receptionist	0	0	0	0	0	0	0	0	0	0	0	0
Bookkeeper	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	78,000	78,000	78,000	79,560	81,151	82,774	84,429	86,118	87,840	89,597	91,389	93,217

Additional Fixed Costs

The following additional fixed annual costs are incorporated into the financial analysis:

taxes and Insurance	$1,524,586
miscellaneous fixed costs	$ 150,010

These costs have been inflated at a rate of 2% per year, starting in year 4.

Federal Income Taxes

It is anticipated that the facility will be set up as a limited partnership and, as such, there are no taxes charged directly to the partnership. The financial projections do, however, provide for a deduction for corporate income taxes at the 35% rate. It will be necessary to distribute to the partners an amount equal to the tax effect of the "pass through" earnings. Therefore, a deduction prior to the net income for income tax is shown.

Pro Forma - Base Case

The Base Case Financial Statements provided in subsequent pages are made up of the following:

- Sources and Application of Funds (Year 1)
- Sources and Application of Funds (Year 2)
- Balance Sheet (Years 1 through 12)
- Income Statement (Years 1 through 12)
- Cash Flow Statement (Years 1 through 12)
- Pricing Sensitivity Matrix - Average Annual Pre-tax Income (Years 3 through 12)
- Pricing Sensitivity Matrix - Average Annual Cash Flow (Years 3 through 12)

The cash flow for the proposed project is negative every year, averaging -$17,557,853 in Years 3 through Year 12. Although not provided as part of these financial projections, it should be noted that the project shows a negative cash flow even after the loan has been retired.

After tax income for the project does show improvement, but is never positive. Annual after tax income for Years 3 through Year 12 averages -$22,110,269, representing an average annual return on investment of –14.5%.

Cumulative earnings at the end of Year 12 are -$240,615,368.

SOURCES AND APPLICATION OF FUNDS
YEAR 1

NREL - Biomass to Ethanol Facility at Chief Ethanol Fuels **BASE CASE**

SOURCES AND APPLICATION OF FUNDS (YEAR 1)	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11	Month 12	Total
CASH INFLOW													
PRODUCTION UNITS													
Fuel Ethanol (gal)													0
Carbon Dioxide (tons)													0
Electricity (kWh)													0
INVENTORY-FINISHED PRODUCTS													
Fuel Ethanol (gal)													
Carbon Dioxide (tons)													
Electricity (kWh)													
SALES UNITS													
Fuel Ethanol (gal)													0
Carbon Dioxide (tons)													0
Electricity (kWh)													0
SALES DOLLARS													
Fuel Ethanol													0
Carbon Dioxide													0
Electricity													0
Total Sales	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
ACCOUNTS RECEIVABLE	0	0	0	0	0	0	0	0	0	0	0	0	0
STATE PRODUCERS INCENTIVE	0	0	0	0	0	0	0	0	0	0	0	0	0
INCOMING CASH													
COLLECTIONS												0	0
EQUITY	45,737,568												45,737,568
SUBORDINATED DEBT													0
OTHER FINANCING													0
PROJECT FINANCING	0	2,893,894	4,785,502	4,825,381	4,865,592	4,906,139	4,947,024	4,988,249	5,029,817	5,071,733	5,113,997	5,156,614	52,583,939
Total incoming cash	**45,737,568**	**2,893,894**	**4,785,502**	**4,825,381**	**4,865,592**	**4,906,139**	**4,947,024**	**4,988,249**	**5,029,817**	**5,071,733**	**5,113,997**	**5,156,614**	**98,321,506**
DISBURSEMENTS													
Construction draws	41,579,607	4,615,336	4,615,336	4,615,336	4,615,336	4,615,336	4,615,336	4,615,336	4,615,336	4,615,336	4,615,336	4,615,336	92,348,303
Loan commitment fees	2,134,420												2,134,420
Stover													0
Chemicals													0
Process water													0
Disposal													0
Electricity													0
Natural Gas													0
Maintenance													0
Plant salaries and benefits	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes and insurance	127,049	127,049	127,049	127,049	127,049	127,049	127,049	127,049	127,049	127,049	127,049	127,049	1,524,586
Administrative salaries and benefits	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	78,000
Miscellaneous	12,501	12,501	12,501	12,501	12,501	12,501	12,501	12,501	12,501	12,501	12,501	12,501	150,010
Interest expense	0	0	24,116	63,995	104,206	144,753	185,638	226,863	268,431	310,347	352,611	395,228	2,076,188
Total disbursements	**43,860,076**	**4,761,386**	**4,785,502**	**4,825,381**	**4,865,592**	**4,906,139**	**4,947,024**	**4,988,249**	**5,029,817**	**5,071,733**	**5,113,997**	**5,156,614**	**98,311,506**
Beginning cash	0	1,877,491	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	0
Total receipts	45,737,568	2,893,894	4,785,502	4,825,381	4,865,592	4,906,139	4,947,024	4,988,249	5,029,817	5,071,733	5,113,997	5,156,614	98,321,506
Total disbursements	43,860,076	4,761,386	4,785,502	4,825,381	4,865,592	4,906,139	4,947,024	4,988,249	5,029,817	5,071,733	5,113,997	5,156,614	98,311,506
Ending cash	**1,877,491**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**
Note balance	**0**	**2,893,894**	**7,679,396**	**12,504,777**	**17,370,368**	**22,276,507**	**27,223,530**	**32,211,779**	**37,241,596**	**42,313,328**	**47,427,325**	**52,583,939**	
Interest rate	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	
Interest expense	0	24,116	63,995	104,206	144,753	185,638	226,863	268,431	310,347	352,611	395,228	438,199	

SOURCES AND APPLICATION OF FUNDS
YEAR 2

NREL - Biomass to Ethanol Facility at Chief Ethanol Fuels **BASE CASE**

SOURCES AND APPLICATION OF FUNDS (YEAR 2)	Month 13	Month 14	Month 15	Month 16	Month 17	Month 18	Month 19	Month 20	Month 21	Month 22	Month 23	Month 24	Total
CASH INFLOW													
PRODUCTION UNITS													
Fuel Ethanol (gal)							586,645	1,368,839	1,955,484	1,955,484	1,955,484	1,955,484	9,777,420
Carbon Dioxide (tons)							1,770	4,130	5,900	5,900	5,900	5,900	29,500
Electricity (kWh)							299	699	998	998	998	998	4,990
INVENTORY-FINISHED PRODUCTS													
Fuel Ethanol (gal)							100,000	100,000	100,000	100,000	100,000	100,000	
Carbon Dioxide (tons)							300	300	300	300	300	300	
Electricity (kWh)							0	0	0	0	0	0	
SALES UNITS													
Fuel Ethanol (gal)							486,645	1,368,839	1,955,484	1,955,484	1,955,484	1,955,484	9,677,420
Carbon Dioxide (tons)							1,470	4,130	5,900	5,900	5,900	5,900	29,200
Electricity (kWh)							299	699	998	998	998	998	4,990
SALES DOLLARS													
Fuel Ethanol							559,642	1,574,165	2,248,807	2,248,807	2,248,807	2,248,807	11,129,035
Carbon Dioxide							0	0	0	0	0	0	0
Electricity							0	0	0	0	0	0	0
Total Sales							**559,642**	**1,574,165**	**2,248,807**	**2,248,807**	**2,248,807**	**2,248,807**	**11,129,035**
ACCOUNTS RECEIVABLE	0	0	0	0	0	0	559,642	1,574,165	2,248,807	2,248,807	2,248,807	2,248,807	2,248,807
STATE PRODUCERS INCENTIVE	0	0	0	0	0	0	0	0	0	0	0	0	0
INCOMING CASH													
COLLECTIONS	0	0	0	0	0	0	0	559,642	1,574,165	2,248,807	2,248,807	2,248,807	8,880,228
EQUITY													0
SUBORDINATED DEBT													0
OTHER FINANCING													0
PROJECT FINANCING	5,206,627	5,250,016	5,292,768	5,338,871	5,457,113	5,763,037	6,974,453	16,857,565	(2,003,396)	0	0	0	54,137,053
Total incoming cash	**5,206,627**	**5,250,016**	**5,292,768**	**5,338,871**	**5,457,113**	**5,763,037**	**6,974,453**	**17,417,207**	**(429,231)**	**2,248,807**	**2,248,807**	**2,248,807**	**63,017,281**
DISBURSEMENTS													
Construction draws	4,615,336	4,615,336	4,615,336	4,615,336	4,615,336	4,615,336	4,615,336	13,943,035					46,250,387
Loan commitment fees													0
Stover						260,449	339,514	1,358,054	1,584,397	1,131,712	1,131,712	1,131,712	6,937,550
Chemicals							932,906	932,906	932,906	932,906	932,906	932,906	5,597,436
Process water							15,991	15,991	15,991	15,991	15,991	15,991	95,946
Disposal							21,840	21,840	21,840	21,840	21,840	21,840	131,040
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural Gas							66,878	66,878	66,878	66,878	66,878	66,878	401,268
Maintenance	0	0	0	0	0	0	36,473	85,104	121,578	121,578	121,578	121,578	607,889
Plant salaries and benefits	7,042	7,042	7,042	7,042	81,792	81,792	92,030	81,792	81,792	81,792	81,792	81,792	692,742
Taxes and insurance	127,049	127,049	127,049	127,049	127,049	127,049	127,049	127,049	127,049	127,049	127,049	127,049	1,524,586
Administrative salaries and benefits	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	78,000
Miscellaneous	12,501	12,501	12,501	12,501	12,501	12,501	12,501	12,501	12,501	12,501	12,501	12,501	150,010
Interest expense	438,199	481,588	525,338	569,445	613,935	659,411	707,436	765,557	906,037	889,342	889,342	889,342	8,334,972
Total disbursements	**5,206,627**	**5,250,016**	**5,293,766**	**5,337,873**	**5,457,113**	**5,763,037**	**6,974,453**	**17,417,207**	**3,877,468**	**3,408,089**	**3,408,089**	**3,408,089**	**70,801,825**
Beginning cash	10,000	10,000	10,000	9,002	10,000	10,000	10,000	10,000	10,000	(4,296,699)	(5,455,981)	(6,615,262)	10,000
Total receipts	5,206,627	5,250,016	5,292,768	5,338,871	5,457,113	5,763,037	6,974,453	17,417,207	(429,231)	2,248,807	2,248,807	2,248,807	63,017,281
Total disbursements	5,206,627	5,250,016	5,293,766	5,337,873	5,457,113	5,763,037	6,974,453	17,417,207	3,877,468	3,408,089	3,408,089	3,408,089	70,801,825
Ending cash	**10,000**	**10,000**	**9,002**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**	**(4,296,699)**	**(5,455,981)**	**(6,615,262)**	**(7,774,544)**	**(7,774,544)**
Note balance	**57,790,565**	**63,040,581**	**68,333,348**	**73,672,219**	**79,129,332**	**84,892,369**	**91,866,822**	**108,724,387**	**106,720,992**	**106,720,992**	**106,720,992**	**106,720,992**	
Interest rate	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	
Interest expense	481,588	525,338	569,445	613,935	659,411	707,436	765,557	906,037	889,342	889,342	889,342	889,342	

BALANCE SHEET

NREL - Biomass to Ethanol Facility at Chief Ethanol Fuels **BASE CASE**

BALANCE SHEET	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10	YEAR 11	YEAR 12
Assets												
Current Assets												
Cash	10,000	86,167,698	68,915,746	51,599,375	34,217,296	16,768,196	(749,267)	(18,336,460)	(35,994,775)	(53,725,638)	(71,530,498)	(89,410,835)
Accounts receivable	0	2,248,807	2,293,783	2,339,659	2,386,452	2,434,181	2,482,865	2,532,522	2,583,172	2,634,836	2,687,533	2,741,283
State Producers Incentive	0	0	0	0	0	0	0	0	0	0	0	0
Inventory	0	482,249	491,894	501,732	511,766	522,002	532,442	543,090	553,952	565,031	576,332	587,859
Reserve for Capital Expenses		0	0	0	0	0	0	0	0	0	0	0
Total Current Assets	**10,000**	**88,898,754**	**71,701,423**	**54,440,765**	**37,115,514**	**19,724,378**	**2,266,040**	**(15,260,847)**	**(32,857,650)**	**(50,525,771)**	**(68,266,634)**	**(86,081,694)**
Property, Plant & Equipment												
Plant equipment	94,424,491	143,962,794	143,962,794	143,962,794	143,962,794	143,962,794	143,962,794	143,962,794	143,962,794	143,962,794	143,962,794	143,962,794
Construction in progress												
Accumulated depreciation	0	9,597,520	19,195,040	28,792,560	38,390,080	47,987,600	57,585,120	67,182,640	76,780,160	86,377,680	95,975,200	105,572,720
Net Plant Value	**94,424,491**	**134,365,274**	**124,767,754**	**115,170,234**	**105,572,714**	**95,975,194**	**86,377,674**	**76,780,154**	**67,182,634**	**57,585,114**	**47,987,594**	**38,390,074**
Other Assets												
Organizational costs	1,752,596	2,820,645	2,820,645	2,820,645	2,820,645	2,820,645	2,820,645	2,820,645	2,820,645	2,820,645	2,820,645	2,820,645
Accumulated amortization	0	564,129	1,128,258	1,692,387	2,256,516	2,820,645	2,820,645	2,820,645	2,820,645	2,820,645	2,820,645	2,820,645
Loan acquisition costs	2,134,420	2,134,420	2,134,420	2,134,420	2,134,420	2,134,420	2,134,420	2,134,420	2,134,420	2,134,420	2,134,420	2,134,420
Accumulated amortization	142,295	284,589	426,884	569,179	711,473	853,768	996,063	1,138,357	1,280,652	1,422,947	1,565,241	1,707,536
Total Other Assets	**3,744,721**	**4,106,347**	**3,399,923**	**2,693,499**	**1,987,076**	**1,280,652**	**1,138,357**	**996,063**	**853,768**	**711,473**	**569,179**	**426,884**
Total Assets	**98,179,212**	**227,370,375**	**199,869,100**	**172,304,499**	**144,675,304**	**116,980,225**	**89,782,071**	**62,515,370**	**35,178,752**	**7,770,817**	**(19,709,861)**	**(47,264,735)**
Liabilities and Partners' Equity												
Current Liabilities												
Income Taxes Payable												
Current portion of long-term debt		3,358,913	3,694,804	4,064,284	4,470,713	4,917,784	5,409,562	5,950,519	6,545,571	7,200,128	7,920,140	8,712,154
Total Current Liabilities	**0**	**3,358,913**	**3,694,804**	**4,064,284**	**4,470,713**	**4,917,784**	**5,409,562**	**5,950,519**	**6,545,571**	**7,200,128**	**7,920,140**	**8,712,154**
Long-Term Liabilities												
Project financing	52,583,939	106,720,992	103,362,079	99,667,275	95,602,991	91,132,278	86,214,494	80,804,931	74,854,413	68,308,842	61,108,714	53,188,574
Subordinated Debt												
Other loan												
Less current portion		(3,358,913)	(3,694,804)	(4,064,284)	(4,470,713)	(4,917,784)	(5,409,562)	(5,950,519)	(6,545,571)	(7,200,128)	(7,920,140)	(8,712,154)
Total Long-Term Liabilities	**52,583,939**	**103,362,079**	**99,667,275**	**95,602,991**	**91,132,278**	**86,214,494**	**80,804,931**	**74,854,413**	**68,308,842**	**61,108,714**	**53,188,574**	**44,476,420**
Partners' Equity												
Equity	45,737,568	45,737,568	45,737,568	45,737,568	45,737,568	45,737,568	45,737,568	45,737,568	45,737,568	45,737,568	45,737,568	45,737,568
Accumulated earnings	(142,295)	(19,512,675)	(43,655,037)	(67,524,835)	(91,089,745)	(114,314,112)	(136,594,481)	(158,451,620)	(179,837,719)	(200,700,084)	(220,980,634)	(240,615,368)
Total Partners' Equity	**45,595,273**	**26,224,893**	**2,082,531**	**(21,787,267)**	**(45,352,177)**	**(68,576,544)**	**(90,856,914)**	**(112,714,053)**	**(134,100,151)**	**(154,962,516)**	**(175,243,066)**	**(194,877,800)**
Total Liabilities and Equity	**98,179,212**	**132,945,884**	**105,444,609**	**77,880,008**	**50,250,813**	**22,555,734**	**(4,642,420)**	**(31,909,121)**	**(59,245,739)**	**(86,653,674)**	**(114,134,352)**	**(141,689,226)**

INCOME STATEMENT

NREL - Biomass to Ethanol Facility at Chief Ethanol Fuels **BASE CASE**

INCOME STATEMENT	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10	YEAR 11	YEAR 12
Sales												
Fuel Ethanol	0	11,129,035	26,985,675	27,525,389	28,075,897	28,637,415	29,210,163	29,794,366	30,390,253	30,998,058	31,618,019	32,250,379
Carbon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0
Electricity	0	0	0	0	0	0	0	0	0	0	0	0
Total Sales	**0**	**11,129,035**	**26,985,675**	**27,525,389**	**28,075,897**	**28,637,415**	**29,210,163**	**29,794,366**	**30,390,253**	**30,998,058**	**31,618,019**	**32,250,379**
State Producers Incentive	0	0	0	0	0	0	0	0	0	0	0	0
Total Income	**0**	**11,129,035**	**26,985,675**	**27,525,389**	**28,075,897**	**28,637,415**	**29,210,163**	**29,794,366**	**30,390,253**	**30,998,058**	**31,618,019**	**32,250,379**
Cost of sales												
Stover	0	6,937,550	13,580,539	13,852,150	14,129,193	14,411,777	14,700,013	14,994,013	15,293,893	15,599,771	15,911,766	16,230,001
Chemicals	0	5,597,436	11,194,867	11,418,765	11,647,140	11,880,083	12,117,685	12,360,039	12,607,240	12,859,385	13,116,573	13,378,904
Process water	0	95,946	191,895	195,733	199,648	203,641	207,714	211,868	216,105	220,427	224,836	229,333
Disposal	0	131,040	262,080	267,322	272,668	278,121	283,683	289,357	295,144	301,047	307,068	313,209
Electricity	0	0	0	0	0	0	0	0	0	0	0	0
Natural Gas	0	401,268	802,531	818,581	834,953	851,652	868,685	886,059	903,780	921,856	940,293	959,099
Maintenance	0	607,889	1,385,987	1,413,707	1,441,981	1,470,821	1,500,237	1,530,242	1,560,847	1,592,064	1,623,905	1,656,383
Plant salaries and benefits	0	500,990	981,500	1,001,130	1,021,153	1,041,576	1,062,408	1,083,656	1,105,329	1,127,436	1,149,985	1,172,985
Depreciation	0	9,597,520	9,597,520	9,597,520	9,597,520	9,597,520	9,597,520	9,597,520	9,597,520	9,597,520	9,597,520	9,597,520
Total Cost of Sales	**0**	**23,869,638**	**37,996,919**	**38,564,908**	**39,144,256**	**39,735,191**	**40,337,945**	**40,952,754**	**41,579,858**	**42,219,506**	**42,871,946**	**43,537,434**
Gross Margin	**0**	**(12,740,603)**	**(11,011,244)**	**(11,039,519)**	**(11,068,359)**	**(11,097,776)**	**(11,127,782)**	**(11,158,388)**	**(11,189,605)**	**(11,221,448)**	**(11,253,927)**	**(11,287,055)**
General & Administrative Costs												
Taxes and insurance	0	762,293	1,524,586	1,555,077	1,586,179	1,617,903	1,650,261	1,683,266	1,716,931	1,751,270	1,786,295	1,822,021
Administrative salaries and benefits	0	39,000	78,000	79,560	81,151	82,774	84,429	86,118	87,840	89,597	91,389	93,217
Miscellaneous	0	75,005	150,010	153,010	156,070	159,191	162,375	165,623	168,935	172,314	175,760	179,275
Interest expense	0	5,047,056	10,672,099	10,336,208	9,966,727	9,560,299	9,113,228	8,621,449	8,080,493	7,485,441	6,830,884	6,110,871
Amortization-Loan Fees	142,295	142,295	142,295	142,295	142,295	142,295	142,295	142,295	142,295	142,295	142,295	142,295
Amortization-Start-up Expenses	0	564,129	564,129	564,129	564,129	564,129	0	0	0	0	0	0
Total Gen. & Admin. Expenses	**142,295**	**6,629,777**	**13,131,118**	**12,830,279**	**12,496,551**	**12,126,591**	**11,152,587**	**10,698,751**	**10,196,494**	**9,640,917**	**9,026,623**	**8,347,679**
Pre-Tax Income	**(142,295)**	**(19,370,380)**	**(24,142,362)**	**(23,869,798)**	**(23,564,910)**	**(23,224,367)**	**(22,280,369)**	**(21,857,139)**	**(21,386,099)**	**(20,862,365)**	**(20,280,550)**	**(19,634,734)**
Income taxes-35%												
Net Income	**(142,295)**	**(19,370,380)**	**(24,142,362)**	**(23,869,798)**	**(23,564,910)**	**(23,224,367)**	**(22,280,369)**	**(21,857,139)**	**(21,386,099)**	**(20,862,365)**	**(20,280,550)**	**(19,634,734)**
Cumulative pre-tax earnings	(142,295)	(19,512,675)	(43,655,037)	(67,524,835)	(91,089,745)	(114,314,112)	(136,594,481)	(158,451,620)	(179,837,719)	(200,700,084)	(220,980,634)	(240,615,368)
Cumulative earnings	(142,295)	(19,512,675)	(43,655,037)	(67,524,835)	(91,089,745)	(114,314,112)	(136,594,481)	(158,451,620)	(179,837,719)	(200,700,084)	(220,980,634)	(240,615,368)

CASH FLOW STATEMENT

NREL - Biomass to Ethanol Facility at Chief Ethanol Fuels **BASE CASE**

CASH FLOW STATEMENT	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10	YEAR 11	YEAR 12
Cash Flow From Operations												
Net income	(142,295)	(19,370,380)	(24,142,362)	(23,869,798)	(23,564,910)	(23,224,367)	(22,280,369)	(21,857,139)	(21,386,099)	(20,862,365)	(20,280,550)	(19,634,734)
Adjustments to Reconcile Net Income												
to Net Cash Provided by Operations												
Depreciation	0	9,597,520	9,597,520	9,597,520	9,597,520	9,597,520	9,597,520	9,597,520	9,597,520	9,597,520	9,597,520	9,597,520
Amortization	142,295	706,424	706,424	706,424	706,424	706,424	142,295	142,295	142,295	142,295	142,295	142,295
Net (Increase) Decrease in Operating Assets:												
Accounts receivable	0	(2,248,807)	(44,976)	(45,876)	(46,793)	(47,729)	(48,684)	(49,657)	(50,650)	(51,663)	(52,697)	(53,751)
State Producers Incentive	0	0	0	0	0	0	0	0	0	0	0	0
Inventories	0	(482,249)	(9,645)	(9,838)	(10,035)	(10,235)	(10,440)	(10,649)	(10,862)	(11,079)	(11,301)	(11,527)
Net Increase (Decrease) in Operating Liabilities:												
Accounts payable												
Other current liabilities			0	0	0	0	0	0	0	0	0	0
Net Cash From Operations	**0**	**(11,797,493)**	**(13,893,040)**	**(13,621,567)**	**(13,317,794)**	**(12,978,387)**	**(12,599,678)**	**(12,177,631)**	**(11,707,796)**	**(11,185,293)**	**(10,604,733)**	**(9,960,197)**
Cash Flows From Investing Activities												
(Increase) Decrease in Property and Equipment	0	(49,538,303)	0	0	0	0	0	0	0	0	0	0
(Increase) Decrease in Organization Costs	(1,752,596)	(1,068,050)	0	0	0	0	0	0	0	0	0	0
(Increase) Decrease in Loan Fees	(2,134,420)	0	0	0	0	0	0	0	0	0	0	0
(Increase) Decrease in Equipment Reserve												
Cash Flows From Financing Operations												
Increase (Decrease) in Equity	45,737,568											
Increase (Decrease) in Long Term Financing	52,583,939	54,137,053	(3,358,913)	(3,694,804)	(4,064,284)	(4,470,713)	(4,917,784)	(5,409,562)	(5,950,519)	(6,545,571)	(7,200,128)	(7,920,140)
Net Increase (Decrease) in Cash	**94,434,491**	**(8,266,793)**	**(17,251,952)**	**(17,316,371)**	**(17,382,079)**	**(17,449,100)**	**(17,517,462)**	**(17,587,193)**	**(17,658,315)**	**(17,730,863)**	**(17,804,860)**	**(17,880,337)**
Cash Balance - Beginning of Period	**0**	**94,434,491**	**86,167,698**	**68,915,746**	**51,599,375**	**34,217,296**	**16,768,196**	**(749,267)**	**(18,336,460)**	**(35,994,775)**	**(53,725,638)**	**(71,530,498)**
Cash Balance - End of Period	**94,434,491**	**86,167,698**	**68,915,746**	**51,599,375**	**34,217,296**	**16,768,196**	**(749,267)**	**(18,336,460)**	**(35,994,775)**	**(53,725,638)**	**(71,530,498)**	**(89,410,835)**

Sensitivity Analyses – Base Case

Sensitivity tables for the Base Case generated by various corn stover costs and selling prices for fuel ethanol are provided.

The first table shows the average annual pre-tax income and the second the average annual cash flow for full operating years, with debt service.

Within the expected range of feedstock costs and alcohol revenues, the Base Case does not come close to achieving profitability.

PRICING SENSITIVITY MATRIX
AVERAGE ANNUAL PRE-TAX INCOME (YEARS 3 THROUGH 12)

NREL - Biomass to Ethanol Facility at Chief Ethanol Fuels **BASE CASE**

Ethanol ($/gallon)

Steover $ per ton	0.90	0.95	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40
60.00	($35,097,344)	($33,924,054)	($32,750,764)	($31,577,473)	($30,404,183)	**($29,230,893)**	($28,057,603)	($26,884,313)	($25,711,022)	($24,537,732)	($23,364,442)
58.00	($34,207,266)	($33,033,976)	($31,860,686)	($30,687,395)	($29,514,105)	**($28,340,815)**	($27,167,525)	($25,994,235)	($24,820,944)	($23,647,654)	($22,474,364)
56.00	($33,317,188)	($32,143,898)	($30,970,608)	($29,797,317)	($28,624,027)	**($27,450,737)**	($26,277,447)	($25,104,157)	($23,930,866)	($22,757,576)	($21,584,286)
54.00	($32,427,110)	($31,253,820)	($30,080,530)	($28,907,239)	($27,733,949)	**($26,560,659)**	($25,387,369)	($24,214,079)	($23,040,788)	($21,867,498)	($20,694,208)
52.00	($31,537,032)	($30,363,742)	($29,190,452)	($28,017,161)	($26,843,871)	**($25,670,581)**	($24,497,291)	($23,324,001)	($22,150,710)	($20,977,420)	($19,804,130)
50.00	($30,646,954)	($29,473,664)	($28,300,374)	($27,127,083)	($25,953,793)	**($24,780,503)**	($23,607,213)	($22,433,923)	($21,260,632)	($20,087,342)	($18,914,052)
48.00	($29,756,876)	($28,583,586)	($27,410,296)	($26,237,005)	($25,063,715)	**($23,890,425)**	($22,717,135)	($21,543,845)	($20,370,554)	($19,197,264)	($18,023,974)
46.00	($28,866,798)	($27,693,508)	($26,520,218)	($25,346,927)	($24,173,637)	**($23,000,347)**	($21,827,057)	($20,653,767)	($19,480,476)	($18,307,186)	($17,133,896)
44.00	**($27,976,720)**	**($26,803,430)**	**($25,630,140)**	**($24,456,849)**	**($23,283,559)**	**($22,110,269)**	**($20,936,979)**	**($19,763,689)**	**($18,590,398)**	**($17,417,108)**	**($16,243,818)**
42.00	($27,086,642)	($25,913,352)	($24,740,062)	($23,566,771)	($22,393,481)	**($21,220,191)**	($20,046,901)	($18,873,611)	($17,700,320)	($16,527,030)	($15,353,740)
40.00	($26,196,564)	($25,023,274)	($23,849,984)	($22,676,693)	($21,503,403)	**($20,330,113)**	($19,156,823)	($17,983,533)	($16,810,242)	($15,636,952)	($14,463,662)
38.00	($25,306,486)	($24,133,196)	($22,959,906)	($21,786,615)	($20,613,325)	**($19,440,035)**	($18,266,745)	($17,093,455)	($15,920,164)	($14,746,874)	($13,573,584)
36.00	($24,416,408)	($23,243,118)	($22,069,828)	($20,896,537)	($19,723,247)	**($18,549,957)**	($17,376,667)	($16,203,377)	($15,030,086)	($13,856,796)	($12,683,506)
34.00	($23,526,330)	($22,353,040)	($21,179,750)	($20,006,459)	($18,833,169)	**($17,659,879)**	($16,486,589)	($15,313,299)	($14,140,008)	($12,966,718)	($11,793,428)
32.00	($22,636,252)	($21,462,962)	($20,289,672)	($19,116,381)	($17,943,091)	**($16,769,801)**	($15,596,511)	($14,423,221)	($13,249,930)	($12,076,640)	($10,903,350)
30.00	($21,746,174)	($20,572,884)	($19,399,594)	($18,226,303)	($17,053,013)	**($15,879,723)**	($14,706,433)	($13,533,143)	($12,359,852)	($11,186,562)	($10,013,272)
28.00	($20,856,096)	($19,682,806)	($18,509,516)	($17,336,225)	($16,162,935)	**($14,989,645)**	($13,816,355)	($12,643,065)	($11,469,774)	($10,296,484)	($9,123,194)

PRICING SENSITIVITY MATRIX
AVERAGE ANNUAL CASH FLOW (YEARS 3 THROUGH 12)

NREL - Biomass to Ethanol Facility at Chief Ethanol Fuels **BASE CASE**

Ethanol ($/gallon)

Stover $ per ton	0.90	0.95	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40
60.00	($30,543,280)	($29,369,990)	($28,196,700)	($27,023,409)	($25,850,119)	**($24,676,829)**	($23,503,539)	($22,330,249)	($21,156,958)	($19,983,668)	($18,810,378)
58.00	($29,653,408)	($28,480,118)	($27,306,828)	($26,133,537)	($24,960,247)	**($23,786,957)**	($22,613,667)	($21,440,377)	($20,267,086)	($19,093,796)	($17,920,506)
56.00	($28,763,536)	($27,590,246)	($26,416,956)	($25,243,665)	($24,070,375)	**($22,897,085)**	($21,723,795)	($20,550,505)	($19,377,214)	($18,203,924)	($17,030,634)
54.00	($27,873,664)	($26,700,374)	($25,527,084)	($24,353,793)	($23,180,503)	**($22,007,213)**	($20,833,923)	($19,660,633)	($18,487,342)	($17,314,052)	($16,140,762)
52.00	($26,983,792)	($25,810,502)	($24,637,212)	($23,463,921)	($22,290,631)	**($21,117,341)**	($19,944,051)	($18,770,761)	($17,597,470)	($16,424,180)	($15,250,890)
50.00	($26,093,920)	($24,920,630)	($23,747,340)	($22,574,049)	($21,400,759)	**($20,227,469)**	($19,054,179)	($17,880,889)	($16,707,598)	($15,534,308)	($14,361,018)
48.00	($25,204,048)	($24,030,758)	($22,857,468)	($21,684,177)	($20,510,887)	**($19,337,597)**	($18,164,307)	($16,991,017)	($15,817,726)	($14,644,436)	($13,471,146)
46.00	($24,314,176)	($23,140,886)	($21,967,596)	($20,794,305)	($19,621,015)	**($18,447,725)**	($17,274,435)	($16,101,145)	($14,927,854)	($13,754,564)	($12,581,274)
44.00	**($23,424,304)**	**($22,251,014)**	**($21,077,724)**	**($19,904,433)**	**($18,731,143)**	**($17,557,853)**	**($16,384,563)**	**($15,211,273)**	**($14,037,982)**	**($12,864,692)**	**($11,691,402)**
42.00	($22,534,432)	($21,361,142)	($20,187,852)	($19,014,561)	($17,841,271)	**($16,667,981)**	($15,494,691)	($14,321,401)	($13,148,110)	($11,974,820)	($10,801,530)
40.00	($21,644,560)	($20,471,270)	($19,297,980)	($18,124,689)	($16,951,399)	**($15,778,109)**	($14,604,819)	($13,431,529)	($12,258,238)	($11,084,948)	($9,911,658)
38.00	($20,754,688)	($19,581,398)	($18,408,108)	($17,234,817)	($16,061,527)	**($14,888,237)**	($13,714,947)	($12,541,657)	($11,368,366)	($10,195,076)	($9,021,786)
36.00	($19,864,816)	($18,691,526)	($17,518,236)	($16,344,945)	($15,171,655)	**($13,998,365)**	($12,825,075)	($11,651,785)	($10,478,494)	($9,305,204)	($8,131,914)
34.00	($18,974,944)	($17,801,654)	($16,628,364)	($15,455,073)	($14,281,783)	**($13,108,493)**	($11,935,203)	($10,761,913)	($9,588,622)	($8,415,332)	($7,242,042)
32.00	($18,085,072)	($16,911,782)	($15,738,492)	($14,565,201)	($13,391,911)	**($12,218,621)**	($11,045,331)	($9,872,041)	($8,698,750)	($7,525,460)	($6,352,170)
30.00	($17,195,200)	($16,021,910)	($14,848,620)	($13,675,329)	($12,502,039)	**($11,328,749)**	($10,155,459)	($8,982,169)	($7,808,878)	($6,635,588)	($5,462,298)
28.00	($16,305,328)	($15,132,038)	($13,958,748)	($12,785,457)	($11,612,167)	**($10,438,877)**	($9,265,587)	($8,092,297)	($6,919,006)	($5,745,716)	($4,572,426)

Pro Forma – Target Case

Because the biomass-to-ethanol facility, as presented, is not economically viable, a Target Case Scenario was investigated with the following adjustments to the Base Case:

- Ethanol yield from stover is increased 20%
- Delivered stover price is reduced by $10 per dry U.S. ton
- Chemical costs are reduced from $0.50 to $0.30 per anhydrous ethanol gallon
- Installed cost of the facility is reduced from $6.22 to $3.00 per annual gallon
- Loan interest rate reduced from 10% to the current prime lending rate of 8.5%

The Target Case Scenario Financial Statements provided in subsequent pages are made up of the following:

- Sources and Application of Funds (Year 1)
- Sources and Application of Funds (Year 2)
- Balance Sheet (Years 1 through 12)
- Income Statement (Years 1 through 12)
- Cash Flow Statement (Years 1 through 12)
- Pricing Sensitivity Matrix - Average Annual Pre-tax Income (Years 3 through 12)
- Pricing Sensitivity Matrix - Average Annual Cash Flow (Years 3 through 12)

The Target Case project has steadily increasing positive cash through the years of full operation, averaging $2,160,496 in Years 3 through Year 12. The last year shown in the projections (Year 12) has the largest cash flow, $2,925,051.

After tax income for the project shows steady improvement, averaging $126,286 for Years 3 through Year 12, peaking in Year 12 at $2,115,656. The average annual return on investment for the years of full production is 0.17%.

Cumulative earnings at the end of Year 12 are -$4,444,248.

SOURCES AND APPLICATION OF FUNDS
YEAR 1

NREL - Biomass to Ethanol Facility at Chief Ethanol Fuels **TARGET CASE**

SOURCES AND APPLICATION OF FUNDS (YEAR 1)	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11	Month 12	Total
CASH INFLOW													
PRODUCTION UNITS													
Fuel Ethanol (gal)													0
Carbon Dioxide (tons)													0
Electricity (kWh)													0
INVENTORY-FINISHED PRODUCTS													
Fuel Ethanol (gal)													
Carbon Dioxide (tons)													
Electricity (kWh)													
SALES UNITS													
Fuel Ethanol (gal)													0
Carbon Dioxide (tons)													0
Electricity (kWh)													0
SALES DOLLARS													
Fuel Ethanol													0
Carbon Dioxide													0
Electricity													0
Total Sales	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
ACCOUNTS RECEIVABLE	0	0	0	0	0	0	0	0	0	0	0	0	0
STATE PRODUCERS INCENTIVE	0	0	0	0	0	0	0	0	0	0	0	0	0
INCOMING CASH													
COLLECTIONS												0	0
EQUITY	22,069,589												22,069,589
SUBORDINATED DEBT													0
OTHER FINANCING													0
PROJECT FINANCING	0	1,412,219	2,312,830	2,329,213	2,345,711	2,362,327	2,379,060	2,395,912	2,412,883	2,429,974	2,447,186	2,464,520	25,291,832
Total incoming cash	**22,069,589**	**1,412,219**	**2,312,830**	**2,329,213**	**2,345,711**	**2,362,327**	**2,379,060**	**2,395,912**	**2,412,883**	**2,429,974**	**2,447,186**	**2,464,520**	**47,361,421**
DISBURSEMENTS													
Construction draws	20,063,263	2,227,022	2,227,022	2,227,022	2,227,022	2,227,022	2,227,022	2,227,022	2,227,022	2,227,022	2,227,022	2,227,022	44,560,505
Loan commitment fees	1,029,914												1,029,914
Stover													0
Chemicals													0
Process water													0
Disposal													0
Electricity													0
Natural Gas													0
Maintenance													0
Plant salaries and benefits	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes and insurance	61,304	61,304	61,304	61,304	61,304	61,304	61,304	61,304	61,304	61,304	61,304	61,304	735,653
Administrative salaries and benefits	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	78,000
Miscellaneous	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	96,003
Interest expense	0	0	10,003	26,386	42,884	59,500	76,233	93,085	110,056	127,147	144,359	161,693	851,346
Total disbursements	**21,168,982**	**2,302,827**	**2,312,830**	**2,329,213**	**2,345,711**	**2,362,327**	**2,379,060**	**2,395,912**	**2,412,883**	**2,429,974**	**2,447,186**	**2,464,520**	**47,351,421**
Beginning cash	0	900,607	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	0
Total receipts	22,069,589	1,412,219	2,312,830	2,329,213	2,345,711	2,362,327	2,379,060	2,395,912	2,412,883	2,429,974	2,447,186	2,464,520	47,361,421
Total disbursements	21,168,982	2,302,827	2,312,830	2,329,213	2,345,711	2,362,327	2,379,060	2,395,912	2,412,883	2,429,974	2,447,186	2,464,520	47,351,421
Ending cash	**900,607**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**
Note balance	**0**	**1,412,219**	**3,725,049**	**6,054,261**	**8,399,972**	**10,762,299**	**13,141,358**	**15,537,270**	**17,950,153**	**20,380,126**	**22,827,312**	**25,291,832**	
Interest rate	8.50%	8.50%	8.50%	8.50%	8.50%	8.50%	8.50%	8.50%	8.50%	8.50%	8.50%	8.50%	
Interest expense	0	10,003	26,386	42,884	59,500	76,233	93,085	110,056	127,147	144,359	161,693	179,150	

SOURCES AND APPLICATION OF FUNDS
YEAR 2

NREL - Biomass to Ethanol Facility at Chief Ethanol Fuels **TARGET CASE**

SOURCES AND APPLICATION OF FUNDS (YEAR 2)	Month 13	Month 14	Month 15	Month 16	Month 17	Month 18	Month 19	Month 20	Month 21	Month 22	Month 23	Month 24	Total
CASH INFLOW													
PRODUCTION UNITS													
Fuel Ethanol (gal)							586,645	1,368,839	1,955,484	1,955,484	1,955,484	1,955,484	9,777,420
Carbon Dioxide (tons)							1,770	4,130	5,900	5,900	5,900	5,900	29,500
Electricity (kWh)							250	582	832	832	832	832	4,160
INVENTORY-FINISHED PRODUCTS													
Fuel Ethanol (gal)							100,000	100,000	100,000	100,000	100,000	100,000	
Carbon Dioxide (tons)							300	300	300	300	300	300	
Electricity (kWh)							0	0	0	0	0	0	
SALES UNITS													
Fuel Ethanol (gal)							486,645	1,368,839	1,955,484	1,955,484	1,955,484	1,955,484	9,677,420
Carbon Dioxide (tons)							1,470	4,130	5,900	5,900	5,900	5,900	29,200
Electricity (kWh)							250	582	832	832	832	832	4,160
SALES DOLLARS													
Fuel Ethanol							559,642	1,574,165	2,248,807	2,248,807	2,248,807	2,248,807	11,129,035
Carbon Dioxide							0	0	0	0	0	0	0
Electricity							0	0	0	0	0	0	0
Total Sales							**559,642**	**1,574,165**	**2,248,807**	**2,248,807**	**2,248,807**	**2,248,807**	**11,129,035**
ACCOUNTS RECEIVABLE	0	0	0	0	0	0	559,642	1,574,165	2,248,807	2,248,807	2,248,807	2,248,807	2,248,807
STATE PRODUCERS INCENTIVE	0	0	0	0	0	0	0	0	0	0	0	0	0
INCOMING CASH													
COLLECTIONS	0	0	0	0	0	0	0	559,642	1,574,165	2,248,807	2,248,807	2,248,807	8,880,228
EQUITY													0
SUBORDINATED DEBT													0
OTHER FINANCING													0
PROJECT FINANCING	2,489,019	2,506,650	2,523,407	2,543,278	2,635,044	2,821,422	3,586,118	8,221,848	(1,122,907)	0	0	0	26,203,877
Total incoming cash	**2,489,019**	**2,506,650**	**2,523,407**	**2,543,278**	**2,635,044**	**2,821,422**	**3,586,118**	**8,781,490**	**451,258**	**2,248,807**	**2,248,807**	**2,248,807**	**35,084,105**
DISBURSEMENTS													
Construction draws	2,227,022	2,227,022	2,227,022	2,227,022	2,227,022	2,227,022	2,227,022	6,727,884					22,317,038
Loan commitment fees													0
Stover						167,713	218,626	874,505	1,020,256	728,754	728,754	728,754	4,467,362
Chemicals							561,253	561,253	561,253	561,253	561,253	561,253	3,367,518
Process water							15,991	15,991	15,991	15,991	15,991	15,991	95,946
Disposal							21,840	21,840	21,840	21,840	21,840	21,840	131,040
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural Gas							66,878	66,878	66,878	66,878	66,878	66,878	401,268
Maintenance	0	0	0	0	0	0	17,599	41,065	58,665	58,665	58,665	58,665	293,324
Plant salaries and benefits	7,042	7,042	7,042	7,042	81,792	81,792	92,030	81,792	81,792	81,792	81,792	81,792	692,742
Taxes and insurance	61,304	61,304	61,304	61,304	61,304	61,304	61,304	61,304	61,304	61,304	61,304	61,304	735,653
Administrative salaries and benefits	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	78,000
Miscellaneous	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	96,003
Interest expense	179,150	196,781	214,536	232,411	250,425	269,090	289,075	314,477	372,715	364,761	364,761	364,761	3,412,943
Total disbursements	**2,489,019**	**2,506,650**	**2,524,405**	**2,542,280**	**2,635,044**	**2,821,422**	**3,586,118**	**8,781,490**	**2,275,194**	**1,975,739**	**1,975,739**	**1,975,739**	**36,088,836**
Beginning cash	10,000	10,000	10,000	9,002	10,000	10,000	10,000	10,000	10,000	(1,813,936)	(1,540,868)	(1,267,800)	10,000
Total receipts	2,489,019	2,506,650	2,523,407	2,543,278	2,635,044	2,821,422	3,586,118	8,781,490	451,258	2,248,807	2,248,807	2,248,807	35,084,105
Total disbursements	2,489,019	2,506,650	2,524,405	2,542,280	2,635,044	2,821,422	3,586,118	8,781,490	2,275,194	1,975,739	1,975,739	1,975,739	36,088,836
Ending cash	**10,000**	**10,000**	**9,002**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**	**(1,813,936)**	**(1,540,868)**	**(1,267,800)**	**(994,731)**	**(994,731)**
Note balance	**27,780,850**	**30,287,500**	**32,810,906**	**35,354,184**	**37,989,228**	**40,810,649**	**44,396,768**	**52,618,615**	**51,495,708**	**51,495,708**	**51,495,708**	**51,495,708**	
Interest rate	8.50%	8.50%	8.50%	8.50%	8.50%	8.50%	8.50%	8.50%	8.50%	8.50%	8.50%	8.50%	
Interest expense	196,781	214,536	232,411	250,425	269,090	289,075	314,477	372,715	364,761	364,761	364,761	364,761	

BALANCE SHEET

NREL - Biomass to Ethanol Facility at Chief Ethanol Fuels **TARGET CASE**

BALANCE SHEET	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10	YEAR 11	YEAR 12
Assets												
Current Assets												
Cash	10,000	44,027,607	45,462,859	47,050,839	48,794,602	50,697,263	52,761,999	54,992,053	57,390,730	59,961,403	62,707,511	65,632,562
Accounts receivable	0	2,248,807	2,293,783	2,339,659	2,386,452	2,434,181	2,482,865	2,532,522	2,583,172	2,634,836	2,687,533	2,741,283
State Producers Incentive	0	0	0	0	0	0	0	0	0	0	0	0
Inventory	0	389,513	397,304	405,250	413,355	421,622	430,054	438,655	447,428	456,377	465,504	474,814
Reserve for Capital Expenses		0	0	0	0	0	0	0	0	0	0	0
Total Current Assets	**10,000**	**46,665,927**	**48,153,946**	**49,795,748**	**51,594,409**	**53,553,066**	**55,674,918**	**57,963,230**	**60,421,331**	**63,052,616**	**65,860,548**	**68,848,660**
Property, Plant & Equipment												
Plant equipment	45,411,851	69,071,282	69,071,282	69,071,282	69,071,282	69,071,282	69,071,282	69,071,282	69,071,282	69,071,282	69,071,282	69,071,282
Construction in progress												
Accumulated depreciation	0	4,604,752	9,209,504	13,814,256	18,419,008	23,023,760	27,628,512	32,233,264	36,838,016	41,442,768	46,047,520	50,652,272
Net Plant Value	**45,411,851**	**64,466,530**	**59,861,778**	**55,257,026**	**50,652,274**	**46,047,522**	**41,442,770**	**36,838,018**	**32,233,266**	**27,628,514**	**23,023,762**	**18,419,010**
Other Assets												
Organizational costs	909,656	1,556,235	1,556,235	1,556,235	1,556,235	1,556,235	1,556,235	1,556,235	1,556,235	1,556,235	1,556,235	1,556,235
Accumulated amortization	0	311,247	622,494	933,741	1,244,988	1,556,235	1,556,235	1,556,235	1,556,235	1,556,235	1,556,235	1,556,235
Loan acquisition costs	1,029,914	1,029,914	1,029,914	1,029,914	1,029,914	1,029,914	1,029,914	1,029,914	1,029,914	1,029,914	1,029,914	1,029,914
Accumulated amortization	68,661	137,322	205,983	274,644	343,305	411,966	480,627	549,288	617,948	686,609	755,270	823,931
Total Other Assets	**1,870,909**	**2,137,581**	**1,757,673**	**1,377,765**	**997,857**	**617,948**	**549,288**	**480,627**	**411,966**	**343,305**	**274,644**	**205,983**
Total Assets	**47,292,760**	**113,270,037**	**109,773,396**	**106,430,538**	**103,244,540**	**100,218,536**	**97,666,975**	**95,281,875**	**93,066,563**	**91,024,435**	**89,158,954**	**87,473,653**
Liabilities and Partners' Equity												
Current Liabilities												
Income Taxes Payable												
Current portion of long-term debt		1,824,002	1,979,042	2,147,260	2,329,778	2,527,809	2,742,672	2,975,800	3,228,743	3,503,186	3,800,956	4,124,038
Total Current Liabilities	**0**	**1,824,002**	**1,979,042**	**2,147,260**	**2,329,778**	**2,527,809**	**2,742,672**	**2,975,800**	**3,228,743**	**3,503,186**	**3,800,956**	**4,124,038**
Long-Term Liabilities												
Project financing	25,291,832	51,495,708	49,671,706	47,692,665	45,545,404	43,215,627	40,687,818	37,945,145	34,969,346	31,740,603	28,237,418	24,436,461
Subordinated Debt												
Other loan												
Less current portion		(1,824,002)	(1,979,042)	(2,147,260)	(2,329,778)	(2,527,809)	(2,742,672)	(2,975,800)	(3,228,743)	(3,503,186)	(3,800,956)	(4,124,038)
Total Long-Term Liabilities	**25,291,832**	**49,671,706**	**47,692,665**	**45,545,404**	**43,215,627**	**40,687,818**	**37,945,145**	**34,969,346**	**31,740,603**	**28,237,418**	**24,436,461**	**20,312,423**
Partners' Equity												
Equity	22,069,589	22,069,589	22,069,589	22,069,589	22,069,589	22,069,589	22,069,589	22,069,589	22,069,589	22,069,589	22,069,589	22,069,589
Accumulated earnings	(68,661)	(5,707,111)	(7,379,750)	(8,743,566)	(9,782,305)	(10,478,530)	(10,502,283)	(10,144,711)	(9,384,223)	(8,197,609)	(6,559,904)	(4,444,248)
Total Partners' Equity	**22,000,928**	**16,362,478**	**14,689,839**	**13,326,023**	**12,287,284**	**11,591,059**	**11,567,307**	**11,924,878**	**12,685,366**	**13,871,980**	**15,509,685**	**17,625,341**
Total Liabilities and Equity	**47,292,760**	**67,858,186**	**64,361,545**	**61,018,687**	**57,832,689**	**54,806,685**	**52,255,124**	**49,870,024**	**47,654,712**	**45,612,584**	**43,747,103**	**42,061,802**

INCOME STATEMENT

NREL - Biomass to Ethanol Facility at Chief Ethanol Fuels **TARGET CASE**

INCOME STATEMENT	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10	YEAR 11	YEAR 12
Sales												
Fuel Ethanol	0	11,129,035	26,985,675	27,525,389	28,075,897	28,637,415	29,210,163	29,794,366	30,390,253	30,998,058	31,618,019	32,250,379
Carbon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0
Electricity	0	0	0	0	0	0	0	0	0	0	0	0
Total Sales	**0**	**11,129,035**	**26,985,675**	**27,525,389**	**28,075,897**	**28,637,415**	**29,210,163**	**29,794,366**	**30,390,253**	**30,998,058**	**31,618,019**	**32,250,379**
State Producers Incentive	0	0	0	0	0	0	0	0	0	0	0	0
Total Income	**0**	**11,129,035**	**26,985,675**	**27,525,389**	**28,075,897**	**28,637,415**	**29,210,163**	**29,794,366**	**30,390,253**	**30,998,058**	**31,618,019**	**32,250,379**
Cost of sales												
Stover	0	4,467,362	8,745,044	8,919,945	9,098,344	9,280,311	9,465,917	9,655,235	9,848,340	10,045,307	10,246,213	10,451,137
Chemicals	0	3,367,518	6,735,038	6,869,739	7,007,134	7,147,277	7,290,223	7,436,027	7,584,748	7,736,443	7,891,172	8,048,995
Process water	0	95,946	191,895	195,733	199,648	203,641	207,714	211,868	216,105	220,427	224,836	229,333
Disposal	0	131,040	262,080	267,322	272,668	278,121	283,683	289,357	295,144	301,047	307,068	313,209
Electricity	0	0	0	0	0	0	0	0	0	0	0	0
Natural Gas	0	401,268	802,531	818,581	834,953	851,652	868,685	886,059	903,780	921,856	940,293	959,099
Maintenance	0	293,324	668,775	682,151	695,794	709,710	723,904	738,382	753,150	768,213	783,577	799,249
Plant salaries and benefits	0	500,990	981,500	1,001,130	1,021,153	1,041,576	1,062,408	1,083,656	1,105,329	1,127,436	1,149,985	1,172,985
Depreciation	0	4,604,752	4,604,752	4,604,752	4,604,752	4,604,752	4,604,752	4,604,752	4,604,752	4,604,752	4,604,752	4,604,752
Total Cost of Sales	**0**	**13,862,199**	**22,991,616**	**23,359,353**	**23,734,446**	**24,117,040**	**24,507,286**	**24,905,336**	**25,311,348**	**25,725,481**	**26,147,896**	**26,578,759**
Gross Margin	**0**	**(2,733,164)**	**3,994,060**	**4,166,036**	**4,341,451**	**4,520,375**	**4,702,877**	**4,889,030**	**5,078,905**	**5,272,577**	**5,470,123**	**5,671,620**
General & Administrative Costs												
Taxes and insurance	0	367,826	735,653	750,366	765,373	780,680	796,294	812,220	828,464	845,033	861,934	879,173
Administrative salaries and benefits	0	39,000	78,000	79,560	81,151	82,774	84,429	86,118	87,840	89,597	91,389	93,217
Miscellaneous	0	48,001	96,003	97,923	99,881	101,879	103,917	105,995	108,115	110,277	112,483	114,733
Interest expense	0	2,070,550	4,377,135	4,222,095	4,053,876	3,871,359	3,673,328	3,458,465	3,225,337	2,972,394	2,697,951	2,400,180
Amortization-Loan Fees	68,661	68,661	68,661	68,661	68,661	68,661	68,661	68,661	68,661	68,661	68,661	68,661
Amortization-Start-up Expenses	0	311,247	311,247	311,247	311,247	311,247	0	0	0	0	0	0
Total Gen. & Admin. Expenses	**68,661**	**2,905,286**	**5,666,699**	**5,529,852**	**5,380,189**	**5,216,601**	**4,726,629**	**4,531,458**	**4,318,417**	**4,085,962**	**3,832,418**	**3,555,964**
Pre-Tax Income	**(68,661)**	**(5,638,450)**	**(1,672,639)**	**(1,363,816)**	**(1,038,738)**	**(696,226)**	**(23,752)**	**357,572**	**760,488**	**1,186,615**	**1,637,705**	**2,115,656**
Income taxes-35%												
Net Income	**(68,661)**	**(5,638,450)**	**(1,672,639)**	**(1,363,816)**	**(1,038,738)**	**(696,226)**	**(23,752)**	**357,572**	**760,488**	**1,186,615**	**1,637,705**	**2,115,656**
Cumulative pre-tax earnings	(68,661)	(5,707,111)	(7,379,750)	(8,743,566)	(9,782,305)	(10,478,530)	(10,502,283)	(10,144,711)	(9,384,223)	(8,197,609)	(6,559,904)	(4,444,248)
Cumulative earnings	(68,661)	(5,707,111)	(7,379,750)	(8,743,566)	(9,782,305)	(10,478,530)	(10,502,283)	(10,144,711)	(9,384,223)	(8,197,609)	(6,559,904)	(4,444,248)

CASH FLOW STATEMENT

NREL - Biomass to Ethanol Facility at Chief Ethanol Fuels **TARGET CASE**

CASH FLOW STATEMENT	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10	YEAR 11	YEAR 12
Cash Flow From Operations												
Net income	(68,661)	(5,638,450)	(1,672,639)	(1,363,816)	(1,038,738)	(696,226)	(23,752)	357,572	760,488	1,186,615	1,637,705	2,115,656
Adjustments to Reconcile Net Income												
to Net Cash Provided by Operations												
Depreciation	0	4,604,752	4,604,752	4,604,752	4,604,752	4,604,752	4,604,752	4,604,752	4,604,752	4,604,752	4,604,752	4,604,752
Amortization	68,661	379,908	379,908	379,908	379,908	379,908	68,661	68,661	68,661	68,661	68,661	68,661
Net (Increase) Decrease in Operating Assets:												
Accounts receivable	0	(2,248,807)	(44,976)	(45,876)	(46,793)	(47,729)	(48,684)	(49,657)	(50,650)	(51,663)	(52,697)	(53,751)
State Producers Incentive	0	0	0	0	0	0	0	0	0	0	0	0
Inventories	0	(389,513)	(7,790)	(7,946)	(8,105)	(8,267)	(8,432)	(8,601)	(8,773)	(8,949)	(9,128)	(9,310)
Net Increase (Decrease) in Operating Liabilities:												
Accounts payable												
Other current liabilities			0	0	0	0	0	0	0	0	0	0
Net Cash From Operations	**0**	**(3,292,110)**	**3,259,254**	**3,567,022**	**3,891,023**	**4,232,439**	**4,592,545**	**4,972,726**	**5,374,477**	**5,799,416**	**6,249,293**	**6,726,008**
Cash Flows From Investing Activities												
(Increase) Decrease in Property and Equipment	0	(23,659,431)	0	0	0	0	0	0	0	0	0	0
(Increase) Decrease in Organization Costs	(909,656)	(646,580)	0	0	0	0	0	0	0	0	0	0
(Increase) Decrease in Loan Fees	(1,029,914)	0	0	0	0	0	0	0	0	0	0	0
(Increase) Decrease in Equipment Reserve												
Cash Flows From Financing Operations												
Increase (Decrease) in Equity	22,069,589											
Increase (Decrease) in Long Term Financing	25,291,832	26,203,877	(1,824,002)	(1,979,042)	(2,147,260)	(2,329,778)	(2,527,809)	(2,742,672)	(2,975,800)	(3,228,743)	(3,503,186)	(3,800,956)
Net Increase (Decrease) in Cash	**45,421,851**	**(1,394,244)**	**1,435,252**	**1,587,980**	**1,743,763**	**1,902,661**	**2,064,736**	**2,230,054**	**2,398,678**	**2,570,673**	**2,746,108**	**2,925,051**
Cash Balance - Beginning of Period	**0**	**45,421,851**	**44,027,607**	**45,462,859**	**47,050,839**	**48,794,602**	**50,697,263**	**52,761,999**	**54,992,053**	**57,390,730**	**59,961,403**	**62,707,511**
Cash Balance - End of Period	**45,421,851**	**44,027,607**	**45,462,859**	**47,050,839**	**48,794,602**	**50,697,263**	**52,761,999**	**54,992,053**	**57,390,730**	**59,961,403**	**62,707,511**	**65,632,562**

Sensitivity Analyses – Target Case

Sensitivity tables for the Target Case Scenario generated by various corn stover costs and selling prices for fuel ethanol are provided.

The first table shows the average annual pre-tax income and the second the average annual cash flow for full operating years, with debt service.

PRICING SENSITIVITY MATRIX
AVERAGE ANNUAL PRE-TAX INCOME (YEARS 3 THROUGH 12)

NREL - Biomass to Ethanol Facility at Chief Ethanol Fuels **TARGET CASE**

Ethanol ($/gallon)

Stover $ per ton	0.90	0.95	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40
50.00	($12,860,789)	($11,687,499)	($10,514,209)	($9,340,918)	($8,167,628)	**($6,994,338)**	($5,821,048)	($4,647,758)	($3,474,467)	($2,301,177)	($1,127,887)
48.00	($11,970,711)	($10,797,421)	($9,624,131)	($8,450,840)	($7,277,550)	**($6,104,260)**	($4,930,970)	($3,757,680)	($2,584,389)	($1,411,099)	($237,809)
46.00	($11,080,633)	($9,907,343)	($8,734,053)	($7,560,762)	($6,387,472)	**($5,214,182)**	($4,040,892)	($2,867,602)	($1,694,311)	($521,021)	$652,269
44.00	($10,190,555)	($9,017,265)	($7,843,975)	($6,670,684)	($5,497,394)	**($4,324,104)**	($3,150,814)	($1,977,524)	($804,233)	$369,057	$1,542,347
42.00	($9,300,477)	($8,127,187)	($6,953,897)	($5,780,606)	($4,607,316)	**($3,434,026)**	($2,260,736)	($1,087,446)	$85,845	$1,259,135	$2,432,425
40.00	($8,410,399)	($7,237,109)	($6,063,819)	($4,890,528)	($3,717,238)	**($2,543,948)**	($1,370,658)	($197,368)	$975,923	$2,149,213	$3,322,503
38.00	($7,520,321)	($6,347,031)	($5,173,741)	($4,000,450)	($2,827,160)	**($1,653,870)**	($480,580)	$692,710	$1,866,001	$3,039,291	$4,212,581
36.00	($6,630,243)	($5,456,953)	($4,283,663)	($3,110,372)	($1,937,082)	**($763,792)**	$409,498	$1,582,788	$2,756,079	$3,929,369	$5,102,659
34.00	**($5,740,165)**	**($4,566,875)**	**($3,393,585)**	**($2,220,294)**	**($1,047,004)**	**$126,286**	**$1,299,576**	**$2,472,866**	**$3,646,157**	**$4,819,447**	**$5,992,737**
32.00	($4,850,087)	($3,676,797)	($2,503,507)	($1,330,216)	($156,926)	**$1,016,364**	$2,189,654	$3,362,944	$4,536,235	$5,709,525	$6,882,815
30.00	($3,960,009)	($2,786,719)	($1,613,429)	($440,138)	$733,152	**$1,906,442**	$3,079,732	$4,253,022	$5,426,313	$6,599,603	$7,772,893
28.00	($3,069,931)	($1,896,641)	($723,351)	$449,940	$1,623,230	**$2,796,520**	$3,969,810	$5,143,100	$6,316,391	$7,489,681	$8,662,971
26.00	($2,179,853)	($1,006,563)	$166,727	$1,340,018	$2,513,308	**$3,686,598**	$4,859,888	$6,033,178	$7,206,469	$8,379,759	$9,553,049
24.00	($1,289,775)	($116,485)	$1,056,805	$2,230,096	$3,403,386	**$4,576,676**	$5,749,966	$6,923,256	$8,096,547	$9,269,837	$10,443,127
22.00	($399,697)	$773,593	$1,946,883	$3,120,174	$4,293,464	**$5,466,754**	$6,640,044	$7,813,334	$8,986,625	$10,159,915	$11,333,205
20.00	$490,381	$1,663,671	$2,836,961	$4,010,252	$5,183,542	**$6,356,832**	$7,530,122	$8,703,412	$9,876,703	$11,049,993	$12,223,283
18.00	$1,380,459	$2,553,749	$3,727,039	$4,900,330	$6,073,620	**$7,246,910**	$8,420,200	$9,593,490	$10,766,781	$11,940,071	$13,113,361

PRICING SENSITIVITY MATRIX
AVERAGE ANNUAL CASH FLOW (YEARS 3 THROUGH 12)

NREL - Biomass to Ethanol Facility at Chief Ethanol Fuels **TARGET CASE**

Ethanol ($/gallon)

Stover $ per ton	0.90	0.95	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40
50.00	($10,824,931)	($9,651,641)	($8,478,351)	($7,305,060)	($6,131,770)	**($4,958,480)**	($3,785,190)	($2,611,900)	($1,438,609)	($265,319)	$907,971
48.00	($9,935,059)	($8,761,769)	($7,588,479)	($6,415,188)	($5,241,898)	**($4,068,608)**	($2,895,318)	($1,722,028)	($548,737)	$624,553	$1,797,843
46.00	($9,045,187)	($7,871,897)	($6,698,607)	($5,525,316)	($4,352,026)	**($3,178,736)**	($2,005,446)	($832,156)	$341,135	$1,514,425	$2,687,715
44.00	($8,155,315)	($6,982,025)	($5,808,735)	($4,635,444)	($3,462,154)	**($2,288,864)**	($1,115,574)	$57,716	$1,231,007	$2,404,297	$3,577,587
42.00	($7,265,443)	($6,092,153)	($4,918,863)	($3,745,572)	($2,572,282)	**($1,398,992)**	($225,702)	$947,588	$2,120,879	$3,294,169	$4,467,459
40.00	($6,375,571)	($5,202,281)	($4,028,991)	($2,855,700)	($1,682,410)	**($509,120)**	$664,170	$1,837,460	$3,010,751	$4,184,041	$5,357,331
38.00	($5,485,699)	($4,312,409)	($3,139,119)	($1,965,828)	($792,538)	**$380,752**	$1,554,042	$2,727,332	$3,900,623	$5,073,913	$6,247,203
36.00	($4,595,827)	($3,422,537)	($2,249,247)	($1,075,956)	$97,334	**$1,270,624**	$2,443,914	$3,617,204	$4,790,495	$5,963,785	$7,137,075
34.00	**($3,705,955)**	**($2,532,665)**	**($1,359,375)**	**($186,084)**	**$987,206**	**$2,160,496**	**$3,333,786**	**$4,507,076**	**$5,680,367**	**$6,853,657**	**$8,026,947**
32.00	($2,816,083)	($1,642,793)	($469,503)	$703,788	$1,877,078	**$3,050,368**	$4,223,658	$5,396,948	$6,570,239	$7,743,529	$8,916,819
30.00	($1,926,211)	($752,921)	$420,369	$1,593,660	$2,766,950	**$3,940,240**	$5,113,530	$6,286,820	$7,460,111	$8,633,401	$9,806,691
28.00	($1,036,339)	$136,951	$1,310,241	$2,483,532	$3,656,822	**$4,830,112**	$6,003,402	$7,176,692	$8,349,983	$9,523,273	$10,696,563
26.00	($146,467)	$1,026,823	$2,200,113	$3,373,404	$4,546,694	**$5,719,984**	$6,893,274	$8,066,564	$9,239,855	$10,413,145	$11,586,435
24.00	$743,405	$1,916,695	$3,089,985	$4,263,276	$5,436,566	**$6,609,856**	$7,783,146	$8,956,436	$10,129,727	$11,303,017	$12,476,307
22.00	$1,633,277	$2,806,567	$3,979,857	$5,153,148	$6,326,438	**$7,499,728**	$8,673,018	$9,846,308	$11,019,599	$12,192,889	$13,366,179
20.00	$2,523,149	$3,696,439	$4,869,729	$6,043,020	$7,216,310	**$8,389,600**	$9,562,890	$10,736,180	$11,909,471	$13,082,761	$14,256,051
18.00	$3,413,021	$4,586,311	$5,759,601	$6,932,892	$8,106,182	**$9,279,472**	$10,452,762	$11,626,052	$12,799,343	$13,972,633	$15,145,923

Bridge-to-Corn-Ethanol Subcontract Summary Sheet
Vogelbusch U.S.A.
Technical Advisor: M. Ruth

Industrial Partner: Chief Ethanol in Hastings, NE
Other Partners: Farmers, Kearney Area Ag. Producers Association (KAPPA)

Starch to Ethanol Process Information

Feedstock: Milo with some corn
Facility Capacity: 60,000,000 gal/yr
Ethanol Yield: Unknown
Other Products: DDGS

Biomass Process Information

Size of Biomass Process: 23.5 MM gal/yr = 850 dry tonne / day
Ethanol Yield: 300 L/dry tonne = 72.2 gal / dry ton
Feedstock: Corn Stover
Process: Co-current Dilute Acid Prehydrolysis and Enzymatic Hydrolysis
Fermentative Organism: Xylose Fermenting NREL Recombinant *Zymomonas mobilis*
Steam: Produced by biomass burner / turbogenerator
Electricity: Excess electricity is produced by the facility but no sales credit is taken for it.
Other Information: Cellulase enzyme is to be purchased from an external supplier

Links with Existing Facility

Alcohol Storage and Loadout Facilities
Lab Facilities, Maintenance, Management and Administrative Systems
Use of Steam for Start-up

Capital and Operating Costs

Biomass Plant Capital Investment: $152,458,559 = $6.50 / annual gallon
Total Operating Costs: ≈$1.20 / gal ethanol
Feedstock Cost: $44 / dry ton = $0.609 / gal ethanol
Chemical and Disposal Cost: $0.523 / gal ethanol ($0.30 / gal ethanol for purchased cellulase)

Proforma

Solved for Average Annual After-tax Income: ($22,110,269)
Equivalent to Average Annual Return of –14.5%
Ethanol Selling Price: $1.15 / gal
Plant Life: 12 years
Financing: 30% Equity – Loan at 10% with 15 year term
Depreciation: 15 year straight line

SensitivityAnalysis

Increased Yield 20%, Reduced Stover Price $10 / dry ton, Reduced Chemical Costs from ≈$0.50 / gal to $0.30 / gal, Reduced Fixed Capital Investment to $3.00 / annual gallon, Reduced Loan Rate to 8.5%
Solved for Average Annual Pre-tax Income: $126.286
Equivalent to Average Annual Return of 0.17%

Strengths of Subcontract

Design and Costing for Corn Stover Handling
Design and Costing of Vogelbusch Ethanol Separation Technology
Cost of Corn Stover Collection
Engineering Company Verification of Many Equipment Costs

Labor Requirement Calculations

Subcontract Recommendations/Next Steps

Research is necessary to reduce capital expenditure by 50%
Reduce overall chemical costs (including cellulase) by $0.20/gal ethanol
Improve alcohol yield by 20%
Reduce feedstock collection and transportation cost by $10 / dry ton.
Government grants or low rate loans are also needed to commercialize this technology.
Pilot Plant work is required with actual feedstocks
Determine Zymo's tolerance to process upsets
Develop alternative uses for lignin
Explore Sales of CO_2